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ARTS AND SCIENCES

OR

Fourth Division of "The English Cyclopædia,"

CONDUCTED BY

CHARLES KNIGHT.

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THE

ENGLISH CYCLOPÆDIA.

ARTS AND SCIENCES.

O, in the vowel series, if arranged according to the nature of the sound, occupies the position between *a* and *u*. In the hieroglyphical characters it appears, according to Champollion, to have been a picture of an eye, and even in the old Greek alphabet it is occasionally found with a dot in the centre, to represent the pupil, for instance in the Elean Tablet. But for the different forms of the letter see ALPHABET. The changes to which this vowel is liable are numerous.

1. It is convertible with the adjoining vowel *u;* and indeed the two characters seem to have had a common origin. Thus, the old Greek alphabet would appear to have once terminated, like the Hebrew, with *tau*, so as to exclude the *upsilon;* whereas the Etruscans had a *u* but no *o*. Hence the predominance of the *o* in Greek, of the *u* in Latin. Within the limits of the Latin itself the two letters are often interchanged, out of which arises the confusion between the second, or *o*, and the fourth, or *u* declension, to both of which belong *ficus, cibus, senatus, tumultus, ornatus, laurus, domus*, &c. The words *consul* and *consulere* also appear as *cosol* and *cosolere,* and they have both a common root with *solium*, a seat.

The English language, too, has often an *o* written where *u* is heard, as *one, none, once, come, done, won, some.*

2. With *a*. Grimm has pointed out this change as existing between the Latin and Teutonic tongues, as *doma-re, lonous, odium*, &c., compared with *zähm-en, lang, hass*, &c. Hence, too, the double form of the name *Longobardi* and *Langobardi*. So, in Latin, from the root *gno* (*gnosco*) were formed *gnarus* and *ignarus:* and again, from these *narrare* and *ignorare*, in the latter of which the original vowel reappears. Again, with *clarus* is connected *gloria*, as closely as *gratia* with *gratus*. It is probable too that the masculine *bono* and the feminine *bona* were mere dialectic varieties which originally had no distinction of gender. Thus in the Gothic the converse prevails, the forms in *o* being feminine, those in *a* masculine. Lastly, the English and Scotch have many instances of the interchange, as *one, two, stone*, in the one, *ane, twa, stane*, in the other; but perhaps this change belongs to the next head.

3. With the long *ē*, the sound of which must be considered as the same with the English *a*. Hence in Greek, Ευπατωρ, *απατωρ*, &c., from *πατηρ*; and the Latin *sol, cor* correspond with the Greek *ἡλιος*, and *κηρ* (observe too the German *herz*). The town *Nemetum* in Gallia is called by Greek geographers Νεμωσσος, and the German *jener* is in English *yon*.

4. With *ou*. This interchange is virtually the same with the first-mentioned. It is not uncommon in French, as compared with Latin, as *novella, nouvelle; rota, roue; totus, tout*, &c.

5. With *uo*, especially in Italian, as *huomo, buono, luogo, nuovo*, from the Latin *homo, bonus, locus, novus.*

6. With *eu*, in French, as *lieu, feu, jeu, peu, leur, heure, douleur, queue;* from the Latin, *locus, focus, jocus, pauci* (and Italian, *poco*), *illorum, hora, dolor, cauda*, or *coda*.

7. With *au*. This exists within the Latin; as *cauda* and *coda, cautes* and *cotes, caudex* and *codex, Claudius* and *Clodius, plaudo* and *plodo*. So from the Latin *aurum, audere* (whence the frequentative *ausare*), *Aufidus, audire*, the Italians have *oro, osare, Ofanto;* and the French *or, oser, ouir*. Hence too the French pronunciation of the diphthong *au*.

8. With *oa*. Thus, the English words *boat, oath, oak*, must have received their present orthography when both the vowels were pronounced, as they still are in some parts of England, *bo-at, o-ath*, or *boo-at, oo-ath.*

9. With *ue*, as in the Spanish *bueno, luego, fuego, huesped;* from the Latin *bonus, locus, focus, hospes.*

10. An initial *o* with *hue* or *hui*. Hence from the Latin *ostium, ostiarius*, are derived the French *huis, huissier*, and the English *usher*. From the Latin *os*, a bone, *ovum* an egg, the Spaniards have *hueso, huevo*. From the Latin *octo, ostrea*, come the French *huict* or *huit, huistre* or *huître*. From the Latin *hodie*, which appears to have been pronounced as the Italian *oggi*, was formed the French *hui*, in *au-jour-d'-hui.*

11. In the paragraphs numbered 5, 9, and 10, the *o* really takes the sound of the English *w*, or the Greek digamma; and the same is the case in the Greek language itself, as in *οικος, οινος, οιδα*, Οαξος (which is the true reading in Herodotus, iv. 154), for Fικος, Fινος, Fιδα, Fαξος; the first three of which may be compared with the Latin *vicus, vinum video*. Closely allied hereto is the frequent interchange in Latin of *oe* or *oi* with *ū*. [U.]

12. With *ea*, as between German and English. Thus the former language has *strom, brot, gross, tod, drohen;* the latter *stream, bread, great, death, threat*. This same change exists in the English by itself, as *cleave, clove; weave, wove; heal, whole; heat, hot*, &c.

13. With *ei*, pronounced as the English long *i*. This is exceedingly common in the same languages. Compare the German *beide, bein, ein, nein, geist, heim, heiss, kleiden, mannheit, meist, theil, heilig, reihe, speiche, zeichen;* with *both, bone, one, none, ghost, home, hot, clothe, manhood, most, dole, holy, row, spoke* of a wheel, *token*. This change also exists within the English language, as *shine* and *shone; strike* and *stroke; drive* and *drove.*

14. A short *ŏ* with a short *ĕ*. This is particularly common in Greek, and above all in the penult of disyllables. Thus with *νεμω, στελλω, λεγω*, there co-exist the substantive forms *νομος, στολος, λογος*. The Latin commonly prefers the *ŏ* in such words. Hence to the Greek *πεπτω, επι, εννεα* (*εννεFα*), *νεος* (*νεFος*), *εμεω* (*Fεμεω*), correspond the Latin *cŏquus* and *pŏpina, ŏb, nŏvem, nŏvus. vŏmo*. The change of these vowels is exceedingly common when preceded by a *w* sound, especially if an *r* or *l* follow. Hence in Latin, *verto* and *vorto, velle* and *vŏlo, vester* and *voster, vĕto* and *vŏto*. Hence likewise to the Latin *vermis, vellus, verruca*, correspond the English *worm, wool, wart*. Again the German *schwerdt* is in English *sword;* and *vice versâ* the German *ant-wort* is in English *answer;* and lastly, many words of this form are written with an *o* and pronounced with an *e*, as *wort, worm, worth, worse.*

15. For the tendency of the final letter *n* to disappear after *o*, see N.

OAK, ECONOMICAL USES OF. The oak subserves a greater number of useful purposes than almost any other kind of forest tree. All things considered, British oak is more durable than any other timber largely grown in Europe; and hence its enormous employment in the arts. The wood is hard, tough, tolerably flexible, strong without being too heavy, not easy to splinter, and not readily penetrated by water. An experiment once showed that a weight of 10,000 lbs. was required to break an oaken beam 11 feet long by 5 inches square. With twisted grain the wood is admirably suited for posts for houses, mills, engines, and large machines. It bears alternations of wet and dry better than most other woods; oak piles have been known to endure for many centuries. It is excellent for shingles, pales, laths, and casks. The small slow-growing variety is much employed for the spokes of wheels. The young tree yields slender rods, well suited for hoops, walking sticks, and the handles of carters' whips. The great durability of

British oak is illustrated by numerous well-known examples; such as some of the doors, Edward the Confessor's shrine, and the Coronation chair, at Westminster Abbey; fragments of King John's palace at Eltham; the Plantagenet stalls of Gloucester Cathedral; the piles of the old Savoy palace; the piles beneath the buttresses and starlings of Old London Bridge; the wooden church near Ongar; and Cowey stakes near Oatlands,—which were applied to their respective uses at periods varying from five to nineteen hundred years ago. More important, however, than any of these uses of British oak, is its employment in ship-building, with which it is associated in song and metaphor as well as in fact. An oaken vessel or boat, perfectly sound, and nearly as hard as iron, was found a few years ago in the bed of the river Rother, in Kent, where it is supposed to have lain since the time of Alfred the Great. For more than a thousand years British ships have been mainly built of British oak. During the great wars of 1793 to 1815, the consumption was enormous. In 1806 it was calculated that the ships of the navy contained nearly 1,200,000 loads of timber; and that 100,000 loads a year would be required to keep up the strength, by renewals and repairs. It requires 50 acres of land, and about 100 years in time, to grow oak timber sufficient for one 74-gun ship; a fact that will illustrate the value of old forests to our ship-yards. The royal forests of England either do not contain oak trees enough for national use, or they are too badly managed to yield the supply when wanted. As a consequence, large purchases are made nearly every year. A parliamentary return, called for a few years ago, showed that in eleven years (1840 to 1850 inclusive) the average purchase of British oak for the royal dockyards was nearly 9000 loads, varying from 3000 to 20,000 in a year. There are other varieties of oak, besides the British, which yield timber useful for many purposes in the arts. Turkey oak is not so strong and durable as British, but as its grain is more beautiful, and takes a better polish, it is available for ornamental purposes. The American white oak is much used for ship-building and house building, for cask staves, for milk pails, axe handles, &c.; while the wood of the young trees, being very elastic, and susceptible of easy division, is used for many of the purposes of willow, bamboo, or whalebone, in the making of baskets, brooms, chair seats, riddles, and carters' whips. The live oak, or *quercus virens*, is very largely used in the United States for ship-building; it is strong and durable, though in some degree unfavourable on account of its great weight; it is found, also, to be far better than the white oak for the naves and felloes of heavy wheels, and the screws and cogs of mill-wheels. There are other varieties of American oak, used for a great number of purposes, but none equal to British oak for strong and durable timber.

Every part of the oak tree comes to use. The bark is a more valuable tanning agent than any other known substance; and even the leaves and the saw-dust contain an astringent principle which is applicable to the same purpose. The Valonia oak of the Archipelago yields those acorns and cups which constitute the valuable tanning ingredient called *valonia*. The Dyer's oak is the kind which yields the dye-drug, *quercitron bark*. It is from a species of oak, the *quercus liber*, that we obtain that remarkable bark, *cork*, which is so superior to all other substances for the particular purposes to which it is applied. The scarlet dye, called *kermes*, is obtained from an insect which feeds upon one particular sort of oak to which it forms a kind of parasite, clinging to the branches. The black-dye drug *nut gall* is a morbid excrescence, produced by the puncture of a winged insect, in a small species of oak called the *quercus infectoria*. What is called the *oak apple* is a somewhat similar excrescence on the British oak, applicable to the same purposes as the nut gall, but not in so great a degree.

The root of the oak was formerly carved into knife and dagger handles, tobacco boxes, and small implements and instruments of various kinds. It is now frequently cut into veneers, which present a beautifully diversified surface when polished. Oak leaves, gathered green and dried, furnish in some places a winter forage for sheep, deer, and goats. In ordinary gardening, they sometimes serve as a substitute for tanner's bark, in maintaining the heat of hothouses, &c. The acorns of the oak are a valuable produce of our forests. Evelyn used to say, that a peck of acorns with a little bran will increase the weight of a hog a pound per day for two months together; and even if this be a high estimate, it leaves untouched the truth that acorns form an excellent hog-fodder. Acorns form an important part of the food of deer in many English parks. Poultry will eat acorns, raw or boiled.

OAK-BARK. [BARK.]

OAKUM. When the various cables, stays, shrouds, ropes, &c., belonging to a ship have gone through their term of service, and are no longer strong enough to be used, they are cut up into pieces, and then pulled asunder, all the hempen threads being loosened and disentangled one from another. In this state the hempen threads are called *oakum*, which varies in quality according to the kind of rope from which it is produced. The old ropes of a ship are sold to dealers; and when picked into oakum they are again sold to ship-builders. The work of oakum-picking is a kind of forced employment in many prisons. The oakum is sold to the ship-builders in large bundles, and is then spun into loose threads. These threads are of a very primitive kind; a small bundle of fibres is rolled by the hand on a sloping board, till it assumes the form of a loose irregular kind of rope, from half an inch to an inch in thickness. These oakum ropes are used for driving into the crevices or seams in the outside or deck of a ship, to prevent the entrance of sea-water. This process is called *caulking*, and is effected by the aid of a large mallet or hammer and a caulking chisel; by which a dense layer of oakum is forced into the crevice—afterwards to be well tarred. If this process be well conducted, the ship's side is not only rendered waterproof, but is actually strengthened; for every little fissure becomes filled up with a substance little less compact than the timber itself.

OASIS (in Greek, *Ὄασις*, and sometimes *Αὔασις*) is the appellation given to those fertile spots watered by springs and covered with verdure which are scattered about the great sandy deserts of Africa. [DESERT.] In Arabic they are called wadys. The Arabic and the Greek name seem to contain the same root, and possibly the word may be originally a native African term. The most noted oases are in the Libyan desert, namely Augila, Siwah, the great oasis west of Thebes, or El Khargeh, the little oasis, or Wah el Bahryeh, and several smaller ones which are noticed under EGYPT, in GEOG. DIV. Fezzan also may be considered as a great oasis of the Sahara. [FEZZAN; SAHARA, in GEOG. DIV.]

The oases appear to be depressions in the table-land of Libya. On going from the Nile westward, the traveller gradually ascends till he arrives at the summit of an elevated plain, which continues nearly level, or with slight undulations, for a considerable distance, and rises higher on advancing towards the south. The oases are valleys sunk in this plain, and when you descend to one of them you find the level space or plain of the oasis similar to a portion of the valley of Egypt, surrounded by steep hills of limestone at some distance from the cultivated land. The low plain of the oasis is sandstone or clay, and from this last the water rises to the surface and fertilises the country; and as the table-land is higher in the latitude of Thebes than in that of Lower Egypt, we may readily imagine that the water of the oases is conveyed from some elevated point to the south, and being retained by the bed of clay, rises to the surface wherever the limestone superstratum is removed.

OATH. Oaths have been in use in all countries of which we have any exact information, and it is probable that there is no nation which has any clear notion of a Supreme Being, or of superior beings, that does not make use of oaths on certain solemn occasions. An oath may be described generally as an appeal or address to a Superior Being, by which the person making it engages to declare the truth on the occasion on which he takes the oath, or by which he promises to do something hereafter. The person who imposes or receives the oath, imposes or receives it on the supposition that the person making it apprehends some evil consequences to himself from the Superior Being, if he should violate the oath. The person taking the oath may or may not fear such consequences, but the value of the oath in the eyes of him who receives or imposes it consists in the opinion which he has of its influence over the person taking it. An oath may be taken voluntarily, or it may be imposed on a person under certain circumstances by a political superior; or it may be the only condition on which the assertion or declaration of a person shall be admitted as evidence of any fact.

The form of taking the oath has varied greatly in different countries. Among the Greeks (with whom the uplifted hands as if in prayer and the solemn sacrifice and libation marked the religious element, while the placing the hands on the victims or the altars reminded all parties that the deity himself was present, Iliad iii., 276, and iv., 158; Aristoph., Acharn, 148; Thucyd. v., 47) the forms of oaths were almost as various as the occasions. Oaths were often used by them in judicial proceedings. The Dicastæ, who were judges and jurymen, gave their verdict upon oath. The Heliastic oath is stated at length in the speech of Demosthenes against Timocrates (c. 36). It does not appear that the oath was always imposed on witnesses in judicial proceedings; and yet it does appear that sometimes witnesses gave their evidence on oath: perhaps the oath on the part of witnesses was generally voluntary. (Demosth., *Πρὸς Ἄφοβον Ψευδ*, c. 16; *Κατὰ Κόνωνος*, c. 10; Meier and Schömann, 'Att.' Process., p. 675, and Smith's 'Dict. of Gr. and Rom. Antiq.,' arts. Oath (Greek), and *Μαρτυρία*.)

In the Roman jurisprudence an oath was required in some cases from the plaintiff or the defendant, or both. Thus the oath of calumny was required from the plaintiff, which was a solemn declaration that he did not prosecute his suit for any fraudulent or malicious purpose. The offence of false-swearing was *perjurium*, perjury; but it was considered a less offence in a party to a suit when the oath was imposed by a *judex* than when it was voluntary. It does not appear that in civil proceedings witnesses were necessarily examined on oath; but witnesses appear to have been examined on oath in the judicia publica, which were criminal proceedings. (D. 12. 2. C. 1. 1. Brissonii and Calvini Lexic. 'Juramentum;' Bonnier, 'Traité des Preuves,' §§ 338-378.)

The law of England, as a general rule, requires all evidence or testimony for judicial purposes to be given on oath, and all persons may be sworn as witnesses who, being questioned on the occasion of taking the oath, will declare their belief in the existence of God, in a future state of rewards and punishments, and who will further declare their belief that perjury will be punished by the Deity. This rule permits all persons, of all religious persuasions, who profess to have the necessary belief, to be sworn as witnesses; and it excludes all other persons from being witnesses. A Jew, a Mohammedan, and a Hindu may be sworn as witnesses, but they must severally take the oath in that form which is sanctioned by the usage of their country or nation, and which they severally consider to be binding. (Omichund *v.* Barker; Willes's 'Rep.' 541, and 1 Smith's 'Leading Cases.') It follows that a person who avows atheism, or who does not profess such belief as is stated above, cannot be sworn, and consequently cannot be admitted to give testimony for judicial purposes. Children also who are too young to understand the nature of an oath, and adults who are too ignorant or too weak in intellect to understand what is meant by an oath, cannot be sworn as witnesses. The offence of declaring what is false, when a witness is examined upon oath, constitutes perjury: the particular circumstances which must concur in order that false-swearing shall be legal perjury are stated under that head. [PERJURY.]

Declarations made by a person under the apprehension of immediate death are generally admitted as evidence in judicial proceedings, when properly verified, "for the general principle," says Eyre, C.B., "upon which evidence of this kind rests is, that it is of declarations made in extremity, when the party is at the point of death, and when every hope in this world is gone, when every motive to falsehood is silenced, and the mind is induced by the most powerful considerations to speak the truth." A situation so solemn and awful is considered by the law as creating an obligation equal to that imposed by an oath in court. (1 Leach, 502; see also Alderson's remarks in Ashton's case; 2 Lewin, CC. 147). Quakers also, in all civil cases, were allowed by the statute 7 & 8 Wm. III., c. 34, to give their evidence on affirmation; and now the affirmation of Quakers, Moravians, Separatists, and others who having been Quakers or Moravians conscientiously object to taking oaths (3 & 4 Wm. IV., c. 49, and c. 82; and 1 & 2 Vict., c. 77), is admissible in all judicial proceedings, both civil and criminal. (See also 17 and 18 Vict., c. 125, s. 20.) When a defendant in chancery is entitled to privilege of peerage, or as a lord of parliament, he is required to give his answer to a bill upon honour only; and in the case of a corporation, the corporate body defendants put in their answer under their common seal. Other defendants are required to put in their answer upon oath. For other matters connected with judicial evidence, see EVIDENCE.

An oath is required in England in a great many cases besides judicial proceedings, as for instance, on admission to places of public trust, and on a variety of other occasions.

As oaths may be either voluntary or may be imposed by a political superior, so they may be imposed either on extra-judicial or on judicial occasions. Oaths which are imposed on occasion of judicial proceedings are the most frequent in this country, and the occasions are the most important to the interests of society. The principle on which an oath is administered on judicial occasions is this: it is supposed that an additional security is thereby acquired for the veracity of him who takes the oath.

There are occasions on which oaths are treated lightly, on which he who imposes the oath, he who takes it, and the community who are witnesses to it, treat the violation of it as a trivial matter. Such occasions as these furnish Bentham with arguments against the efficacy of oaths on all occasions. Suppose we admit, with Bentham, as we do merely for the sake of the argument, that "on some occasions oaths go with the English clergy for nothing;" and this, notwithstanding the fact, which nobody can doubt, "that among the English clergy believers are more abundant than unbelievers." The kind of oaths "which go for nothing" are not mentioned by Bentham, but they may be conjectured. Now, if all oaths went for nothing with the clergy, or with any other body of men, the dispute would be settled. But this is not the fact. If in any way it has become the positive morality of any body of men that a certain kind of oath should go for nothing, each individual of that body, with respect to that kind of oath, has the opinion of his body. He does not believe that such oath, if broken, will bring on him divine punishment, and therefore such oath *is* an idle ceremony. But if there is any oath, the violation of which he thinks will bring on him divine punishment, his opinion as to that kind of oath is not at all affected by his opinion as to the other kind of oath. Now, oaths taken on judicial occasions are by the mass of mankind considered to be oaths of the latter kind, and therefore they have an influence on the great majority of those who take them. Whether society will in time so far improve as to render it safe to dispense with this ceremony in judicial proceedings, cannot be affirmed or denied; but a legislator who knows what man now is, will require better reasons for the abolition of judicial oaths than Bentham has given. For some able remarks on this part of the subject, the reader is referred to Mr. Best's admirable treatise on the 'Law of Evidence,' 3rd edit., pp. 61-67.

How far the requisition of an oath may be injurious in excluding testimony in certain cases, and how far oaths on solemn and important occasions may be made most efficacious, and in what cases it may be advisable to substitute declarations in lieu of oaths, are not matters of consideration here. It is enough here to show that an oath is a sanction or security to some extent, if the person who takes it fears divine punishment in case he should violate it; and that this, and no other, is the ground on which the oath is imposed.

Indeed it is evident that in English procedure the professed opinion or belief of the person who takes the oath is the only reason for which courts of justice either admit or refuse to receive his evidence; and this is shown by the questions which may be put to a witness when he comes to deliver his evidence in a court of justice. (See L. C. J. Willes's judgment in Omichund *v.* Barker, Willes, 541.)

There is some difficulty in stating accurately how far oaths were required from witnesses in Roman procedure under the republic and the earlier emperors. In addition to what has been stated, the reader may refer to Cicero, 'Pro Q. Rosc. Comoed.,' c. 15, &c.; Noodt, 'Op. Omn.,' ii. 479, 'De Testibus;' to the commentary of Asconius on the Verrine Orations; and to Zimmern's treatise on 'Civil Procedure among the Romans,' §§ 135 & 150. By a constitution of Constantine, all witnesses were required to give their testimony on oath; and this was again declared by a constitution of Justinian. ('Cod.' 4, 20, 9. 16. 19.)

Many persons conscientiously object to the taking of an oath on religious grounds, and particularly with reference to our Saviour's prohibition (Matth., v. 33). On the subject of oaths in general the reader may consult Grotius, 'De Jure,' B. & P., lib. ii., c. 13; Paley's 'Moral Philosophy;' Tyler's 'Origin and History of Oaths;' the 'Law Magazine,' vol. xii.; and the work of Bentham already referred to.

OATS (*Avena sativa*) is a well-known species of the genus *Avena*, a plant of the family of the *Gramineæ*. [AVENA, in NAT. HIST. DIV.] We shall here only consider those varieties which are cultivated for their grain, principally as food for horses, and in some cases for men also, when ground into oatmeal or grits.

The great use of oats, and the ease with which they are raised on almost every kind of soil, from the heaviest loam to the lightest sand, have made them occupy a place in almost every rotation of crops. Before agriculture had been subjected to regular rules, the result of long experience, the land was often sown as long as any return could be obtained, before any means of recruiting it with manure were thought of; and the last crop which would return any increase of the seed was generally oats. After this, the land, no longer repaying the labour of ploughing and sowing, was abandoned, till, by length of time, by the decomposition of roots and weeds, and the replenishment by the action of atmospheric solvents of the store of inorganic matter in a soluble condition, some renewed fertility was produced. The exhausting character of the plant is to some extent explained by the quantity of mineral matter removed from one acre by an ordinary crop of, say 48 bushels: 96 lbs. of soluble silica, 23 lbs. of phosphoric acid, and 36 lbs. of potash are thus taken from the land. Some farmers, on account of the exhausting character of the crop, prefer buying all their oats in the market to raising them on their own land. Where the soil is well adapted to the growth of wheat and barley, which bear a better price, this may be a judicious plan; but as a general rule, it is always more profitable to raise oats for home consumption than to trust to a fluctuating market. With proper management, a crop of oats may give as great a profit on the best land as any other crop, when it is considered that it requires less manure and produces an abundance of straw, which is very fit for the winter food of horses and cattle, especially when aided by roots or other succulent food. There are nearly 2,000,000 acres of oats grown annually in Ireland, nearly 1,000,000 acres in Scotland, and probably 1,250,000 acres in England. This is four times as much as of wheat in Ireland, four times as much as of wheat in Scotland, and one-third as much as of wheat in England. The colder climate of the two former districts over the greater part of their surface is what makes the oat the more prevalent crop.

The best oats are raised in Scotland and in Friesland, and in both countries the land is carefully cultivated. In Scotland, oats are generally sown on a grass layer which has been in that state for some years, and sometimes on old pastures which are broken up for the purpose. The crops exceed in bulk and weight of grain all that the most sanguine person, unacquainted with the system, would expect, and in many seasons, not favourable for the wheat crop, oats are much more profitable. Wherever the land is not of a good quality, and wheat is apt to fail, oats are a much safer crop, especially in retentive soils, as rye is on poor sands.

When oats are sown after turnips, cabbages, or any other green crop, the land should be well ploughed, if the green crop was not consumed on the spot, and a moderate supply of manure will be well repaid by the increased produce. A heavy loam is best suited for oats: they require a certain degree of moisture, and a deep soil is very favourable to their growth. On land which has been trenched, or where the subsoil plough has been used, after careful draining if required, oats will thrive wonderfully, without requiring so rich a soil as barley or wheat. The roots are hardier and have a stronger vegetative power. When once they have struck deep into the soil, a good crop, according to the quality of the land, may be relied on.

When oats are sown after artificial grasses, the land is seldom ploughed more than once, and the seed is sown on the fresh mould which has been turned up; but unless the land be very free from weeds, it would be better to plough the sward with a shallow furrow early in autumn. Before winter the scarifier would break the rotten sward, which might then be buried deep by another ploughing. The land would be ready for sowing early in spring, which is a great advantage, both as to the quality of the oat crop and the earlier harvest, especially in those districts where the latter part of the autumn is apt to be stormy and rainy. The land thus treated would be clean, and the fallow, which is often resorted to of necessity after a crop of oats, might be dispensed with, as the weeds have been destroyed and buried deep.

When oats are sown on light land after turnips, which have been eaten by sheep folded on them, it may be ploughed with as shallow a furrow as will turn in the surface: the preparation for turnips will have sufficiently moved the soil; and the manure of the sheep should not be buried too deep. On poor moist land oats are more profitable than barley. Clover and grass seeds may be sown among them with equal advantage, as they will seldom grow so high as to be laid and smother the young clover; and barley is very apt to fail on land subject to retain the water.

In sowing oats more seed is often used than of any other grain, because, although the plants tiller where they have room, the straw of the second shoots is weaker, and the grain is not ripe so soon as that of the principal stem; but when the plants rise close and thick, there are no tillers, the main stem is stronger, and the corn is more plump and equal. Six bushels of oats are often sown in Scotland and Ireland on an acre; but if they are drilled, three or four bushels are sufficient, and when dibbled, which is sometimes the case in Norfolk and Suffolk, much less seed is used. A good preparation of the land is of more consequence than a superabundance of seed.

In a field where oats are sown broadcast, and covered by the harrows, many seeds remain exposed to the depredation of birds, which soon find them out at a time of the year when food is scarce; but when they are drilled or dibbled, all the seed is buried and germinates, without any loss. When the seed is sown and ploughed in, the same object is attained; but as the furrow must be shallow in order that the seed may not be buried too deep, the land must have been ploughed before to a considerable depth, unless it be after turnips fed off by sheep, in which case ploughing the seed in is often considered a good practice: in either case four bushels of seed per acre is an ample allowance.

When the ground has been well prepared, there is no necessity for weeding or hoeing the crop as it advances; but if large weeds appear, such as charlock, May-weed, docks, or thistles, they must be carefully weeded out, or else the ground will be so infested with their seeds or roots that it will be difficult to eradicate them afterwards. Oats, when fully ripe, are very apt to shed, and many are lost for want of attention. As soon as the straw turns yellow under the panicle, the oats should be reaped, however green the lower part of the straw may be; the straw will be better fodder for cattle, and all the corn will be saved. Oats are generally mown with a scythe, and raked into heaps to dry like hay; but this is a wasteful and slovenly practice. A good crop of oats should be reaped, like wheat, close to the ground, and tied in sheaves. This may now be done perfectly by machine; but if by hand, the scythe, or the heavy hook, or the Hainault scythe, does the work well in the hands of an expert mower, who should be followed by binders, who gather the straw with their hands and lay it regularly on the ground if it be not fit to tie up immediately: the straw should afterwards be tied up into sheaves, and set with the corn uppermost in shocks of ten or twelve sheaves, leaning against each other, and open at bottom, in order to allow the air to pass through. Thus, in a short time the oats become sufficiently dry to be stacked, or carried immediately into the barn. The produce of an acre of oats varies according to the soil and preparation, from four to eight and even ten or twelve quarters.

Of the many varieties of oat now in cultivation, the "Poland" may be named for its early habit and good quality; the "Potato" oat for quality and productiveness; the "Hopetoun" and "Sandy" oats for their bulky growth, abundant yield, and quality: and the "Tartarian" (black and white) for a great quantity of comparatively coarse quality.

Oats ground into a coarse meal form a considerable portion of the food of labourers and many men in the middle ranks of life in Scotland, Ireland, and the north of England. The meal is simply stirred into boiling water with a little salt, until it becomes of the consistency of a hasty-pudding; it is then called porridge; and when eaten with milk or treacle makes a wholesome and palatable food. It is sometimes mixed with the thin liquor of boiled meat, or the water in which cabbages or kale have been boiled, and acquires the denomination of beef-brose or kale-brose. When made into a dough with water, and baked on an iron plate in thin cakes, it makes a bread which is very palatable to those who are accustomed to it, and who often prefer it to wheaten bread. Its use was once almost universal in Scotland, which has in consequence been called the Land of Cakes. In Germany and Switzerland the coarsely bruised oatmeal is put into an oven till it becomes of a brown colour; it is then called haber-meel, and is used in broths and pottages, as the semolina, made from wheat, is used in France and Italy. The coarsely-broken grains, after the husk has been removed, form grits, which are extensively used to make gruel for children and invalids. The quality of oats as food is proved by experience, and has been amply illustrated by scientific research. Its grain contains 46 per cent. of starch, nearly 14 of nitrogen compounds, 6 of oil, 6 of sugar, nearly 4 of gum, besides 24 of husk, &c. And its straw contains 1·8 of nitrogen compounds, besides 66 of woody fibre and other organic matters. These figures were ascertained by Boussingault. The chaff of oats put into a canvas bag forms a good substitute for feather-beds for the poor, and is far more wholesome than feathers, from the ease with which it may be renewed at little or no cost.

In some countries the oats are given to horses in the straw, without threshing them; and where the quantity can be regulated, the practice is good. The horses masticate the corn better in the chaff, and the straw is wholesome; but where horses do hard work, they would be too long in eating a sufficient quantity, and it is better to give them oats threshed and cleaned, with clover hay cut into chaff. When hay is dear, it is often cheaper to increase the quantity of oats, and to give it with wheat-straw cut fine. In this way very little hay is required. The calculation is easily made when we consider that a pound of good oats gives as much nourishment to a horse as two pounds of the best clover, or sainfoin hay. A truss of hay of 56 pounds is therefore equal to 28 pounds of oats; or a bushel of the best oats will go as far as one truss and a half of hay; and if this quantity is worth 4*s.*, which is at the rate of 4*l.* 16*s.* per load of thirty-six trusses, the equivalent price of oats is 32*s.* per quarter.

Farmers who have hay-ricks from which they often allow their men to take as much as they please for their horses, will carefully measure out the oats, which probably are much cheaper. Those who keep many horses should cut all the hay into chaff by a machine, and mixing this with a proper proportion of oats, feed all their horses in mangers with a certain allowance of the mixture, a practice much more economical than that usually adopted. In France and Germany the practice of baking oats, as well as rye, into loaves for horse-food, is gaining ground, and is said to be attended by an evident saving of food.

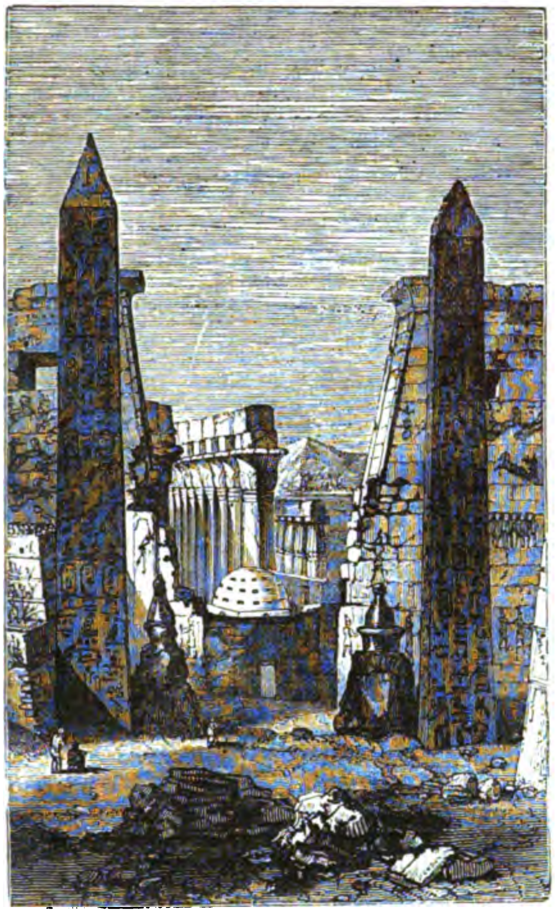
OBELISK, a Greek word used to designate the well-known Egyptian monumental monolith. Obelisk (ὀβελίσκος) is a diminutive of *obelos* (ὀβελος), a sharp-pointed thing, a spit, or skewer; and was no doubt applied to the Egyptian obelisk on account of its shape and pointed end. Herodotus used the word ὀβελίσκος both for an obelisk (ii. 111), and a skewer or spit (ii. 41). The Italian name for an obelisk *aguglia*, and the French *aiguille*, are derived from the Latin *acus*, a needle or pin: a word applied also to the pin or bodkin used for fastening up the hair, and which instead of tapering to a point like a needle, sometimes, at least, had the end sloped off abruptly; as may be seen in Montfaucon, 'Ant.,' supp., plate iii.

The Egyptian obelisk is a tall, monolithic, four-sided shaft, which diminishes gradually from the base to near the top, when the sides are sloped off so as to form a pyramidion, or diminutive pyramid, which serves as the apex. In size, obelisks vary greatly; the shaft of the Lateran obelisk, the largest remaining, is 105 feet high, and was once more; while one at Florence, the smallest known, is under 6 feet in height. The larger Egyptian obelisks are almost invariably made of the red granite of Syene; the small ones of green basalt. Their sides are, with few exceptions, covered with hieroglyphics.

A great deal has been written respecting the origin and purpose of the obelisk, without any very definite result. It may safely be said, however, that the Egyptian obelisk was only a refinement on the stone of memorial which it was the general primitive custom to set up on special occasions or in holy places, of which that raised by Jacob at Bethel (Gen. xxviii. 18) is an instance that will occur to every one. Monoliths are in fact found among all the most ancient races. The Egyptians, a highly cultivated people, gave to theirs an artistic form. The peculiar tapering form and pointed termination were stated by Pliny to have been suggested by a tongue of flame; and the idea of fire, or the worship of the sun, seems to have been by some tradition generally associated among the ancients with the Egyptian obelisk. Be the original idea what it may, the Egyptians somehow succeeded in devising a form which in its way has never been equalled in grace of outline, or, where conjoined with magnitude, in imposing effect.

The Egyptians never placed their obelisks, as the moderns almost invariably do, alone, in a broad open space. They fixed them in pairs in front of the propylæa of a temple, and the hieroglyphics inscribed on their sides told the name and titles of the monarch who erected them, and the purpose of the building before which they stood. They were raised on low oblong bases or pedestals, which, however, were no part of the obelisk proper, but were formed of separate blocks of granite. The position of the obelisk will be understood by the cut of the very fine pair—the most perfect extant—which stood in front of the propylæa of the temple of Luxor: one of these has, since the drawing was made, been removed to Paris. The bases are hidden by the accumulated sand.

The shaft of an Egyptian obelisk is usually about eight, but sometimes ten times as high as the width of the base. The width at the top of the shaft, or base of the pyramidion, is one fourth less than the base of the shaft. The height of the pyramidion is from one to one and a half the width of its base. We have described the shaft as quadrilateral, but it is not square; two of the sides, the front and back, being generally somewhat wider than the other two. Neither are the sides perfectly flat. Under COLUMN and GRECIAN ARCHITECTURE it has been shown that, to atone for a certain optical appearance, the Greeks made the outline of their columns, and other lines which in appearance were right lines, to be in reality very slightly convex. In the same way, and doubtless for a similar reason, that is to counteract a seeming concavity of surface observable in really flat-sided obelisks, the Egyptians made the sides of their obelisks slightly convex, or, as it is technically termed, to have an entasis on the plan. And it is noteworthy that Mr. John Bell, the distinguished sculptor, without being acquainted apparently with the Egyptian practice, was led to give precisely such an entasis to a monumental obelisk constructed by him; as the result of a series of tentative efforts made to overcome a seeming concavity of surface and horizontal plan observed by him in his model, and of which experiment he gave a full account in a paper read before the Institute of Architects, in May, 1858.



Obelisks in front of the Temple of Luxor.

At one time there must have been a large number of obelisks in Egypt, as they are traced all the way from Philæ to the Mediterranean. South of the first cataracts there are none of large size, owing, as is supposed, to the difficulty of conveying such large masses of granite up the river from the quarries of Syene. Since the Romans became masters of Egypt, the obelisks have been made a constant prey, and comparatively few are now left standing. Augustus was the first who removed any of these monoliths: one he caused to be placed in the Campus Martius, another in the Circus. The great obelisk of the Lateran was conveyed from Heliopolis to Alexandria by Constantine, and from thence removed by that emperor's son Constantius to Rome, where it was erected in the Circus Maximus. This obelisk is the largest now known, its shaft being 105 ft. (although it has been reduced, a portion at the lower part having been cut off in consequence of being fractured), and two of its sides, 9 ft. 8½ in., the other two 9 ft.; the shaft weighs about 445 tons. That which was originally brought from Heliopolis, and placed in the Vatican Circus, and which now stands in the piazza of St. Peter's, is next in size to that of the Lateran, though supposed to have been somewhat abridged of its original dimensions. The entire height of the shaft itself is 83 ft.; it is 8 ft. 10 in. square at its base, and 5 ft. 11 in. at the other end. In all 48 obelisks were transported by the emperors to Rome; o these the five largest still remain, but only seven of the smaller ones have escaped destruction.

During the calamities that befel Rome under its barbarian invaders after the downfall of the empire, the obelisks were damaged and overthrown; but those not entirely destroyed have been gradually restored under various pontiffs. The first to attempt this was Sixtus V., and so much interest did the proposal to raise one of these shafts excite, that 500 different plans are said to have been sent in from various parts of Europe. The task was allotted to Dominico Fontana, who employed 600 men and 140 horses in raising it, and was so elated with his success, that he published full details of the process in a handsome folio volume. In all twelve obelisks have been erected in Rome,

but the most entire ignorance or disregard has been shown of the principles which render these monoliths so graceful in their original state. Not only have they been placed on absurdly unsuitable pedestals—one, for instance, on the back of an elephant—but above the original termination (the simple and elegant pyramidion), has been fixed a cross, with other equally misplaced and often puerile ornaments. The following table contains a list of the Roman obelisks, arranged in the order of their modern restoration, with the dimensions of the shafts—but omitting the modern bases and crowning ornaments, and other particulars:—

I. The Vatican, in front of St. Peter's, where it was removed by Fontana from the Vatican Circus. On the side facing the church, and on the opposite side, we see the dedication to Augustus and Tiberius. Height 83 ft. 2 in. Without hieroglyphics, and still entire.

II. In front of the church of Santa Maria Maggiore, erected by Fontana. Height 48 ft. 5·1 in.; without hieroglyphics; broken in three or more places.

III. In front of the St. John Lateran church, erected by Fontana; Height 105 ft. 7 in. Hieroglyphics; broken in three pieces. This magnificent monolith was originally erected before the propylæa of the temple at Thebes by one of the kings of the 18th dynasty.

IV. Flaminio del Popolo, erected by Fontana. Height 78 ft. 6 in. Hieroglyphics; broken in three pieces. This was one of the two obelisks brought by Augustus from Heliopolis. These four obelisks were raised under pope Sixtus V. during the years 1586-89.

V. In the Piazza Navona; sometimes called the Pamphilian obelisk; erected by Innocent X., in 1651. Height 54 ft. 3 in. Has hieroglyphics, but not genuine ones, having been cut by order of Domitian. Fountain round the base.

VI. Minerveo della Minerva, erected by Bernini for Alexander VII., in 1667. This obelisk, with singular bad taste, is placed on the back of a horrible elephant, the work of Bernini. Height about 17 ft. Hieroglyphics.

VII. Mahuteo della Rotonda, raised by order of Clement XI. in 1711, in front of the Pantheon of Agrippa. Height 19 ft. 9 in. Hieroglyphics; probably the pendant of No. 6: fountain round the base.

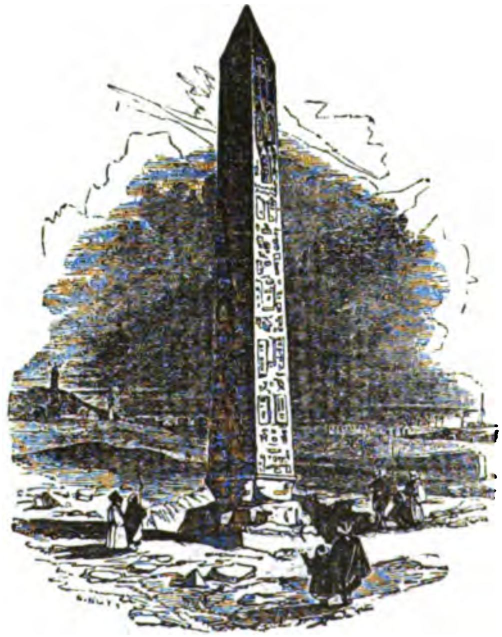
VIII. Quirinale di Monte Cavallo, erected by Antinori for Pius VI., in 1786. Height 47 ft. 8 in. No hieroglyphics; appears broken in two or three places.

IX. Sallustiano della Trinità di Monte, erected by Antinori for Pius VI., in 1789. Height about 43 ft. 6 in. Hieroglyphics.

X. Campense di Monte Citorio, erected by Antinori for Pius VI., in 1792. Height 71 ft. 6 in. Hieroglyphics.

XI. Aureliano della Passeggiata, on the Monte Pincio, erected for Pius VII., in 1822. Height about 30 ft. Hieroglyphics. This is called by Zoëga the Barberini obelisk, of which he says, "Hic e Romanis obeliscis adhuc cognitis solus expectat sospitatorem."

XII. Private obelisk erected in 1817 on the Cœlian Hill, in the gardens of the Villa Mattei; hardly worth mentioning. It is a small fragment of a real obelisk mounted on a piece of modern granite.



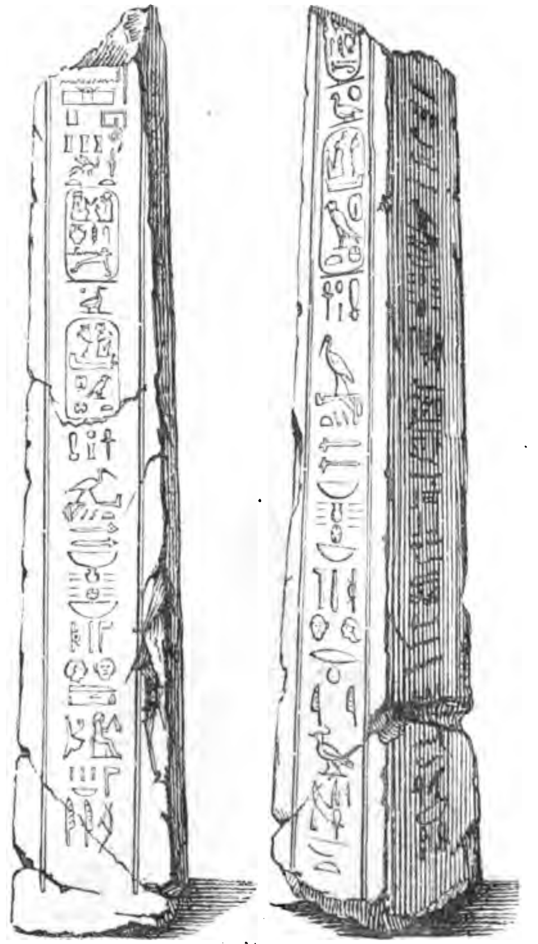
Cleopatra's Needle.

Of the two obelisks which Pliny mentions ('Hist. Nat.,' xxxvi. 9) as standing in front of a temple at Alexandria, only one is now standing, Like most of the monuments of Lower Egypt, it bears the name of the great

Rameses II. The annexed cut (col. 10) of this obelisk, popularly known as Cleopatra's needle, will serve to show the appearance of one of these monuments with its pedestal, as the cut of the Luxor obelisks illustrates their original position. The following are the dimensions of the Alexandrian obelisk:—Width of one base of shaft, 8 ft. 2 in.; width of same face of the obelisk at base of the pyramidion, 5 ft. 2 in.; width of other sides at base of shaft and base of pyramidion, 7 ft. 8·7 in., and 4 ft. 8·5 in., respectively; height of shaft to base of pyramidion, 60 ft. 7·6 in.; height of pyramidion, 6 ft. 6·8 in.; whole height of shaft, 67 ft. 2·4 in.; height of pedestal and plinths, 12 ft.; making the entire height of the obelisk and supports a little over 79 feet. The corresponding obelisk lies on the ground. This one was some time ago presented to the British government, but it was found to be so much damaged as not to be worth the cost of removal.

The largest Egyptian obelisk hitherto brought over to this country is that which was removed from the island of Philæ by Belzoni, at the cost of W. Bankes, Esq., and which is now erected at the family seat, Kingston Hall, near Weymouth, Dorsetshire. It is a monolith of red Egyptian granite, 22 ft. 1 in. in length, and its larger end, or base, 2 ft. 2 in. square, the other end being 1 ft. 5⅜ in. It has a peculiar interest with Egyptologists, from a Greek inscription on its pedestal having enabled Champollion to determine the names of Cleopatra and Ptolemy, "to extend the alphabet, and to lay the foundation for the future decipherment and interpretation of the hieroglyphics." [HIEROGLYPHICS.]

The two small obelisks in the British Museum are also very interesting for their inscriptions, which are admirably executed. We give cuts of them as illustrations of the manner in which the obelisks are engraved: the animals are in the best style of Egyptian hieroglyphic art. They are of green basalt, and about eight feet in height, but as will be seen have been much broken.



The obelisk removed by the French from before the propylæa of the temple of Luxor is the smaller of the two shown *in situ* in the cut above (col. 9). It now stands in the centre of the Place de la Concorde, where it was fixed in 1836.

Before the cathedral of Catania, in Sicily, is a small obelisk, placed on the back of an elephant; and there is one at Arles (see the cut under the article ARLES, in GEOG. DIV.), but these are not really Egyptian, though frequently so described. In the At Meidan, in Constantinople, is an obelisk about 50 feet high, which is said to have been erected by the emperor Theodosius.

Much surprise has been expressed by writers that the Egyptians should have been able to quarry, remove, and raise such vast masses of granite. But the Egyptians were a people whose culture in the arts had reached a high point; they almost beyond any other people had experience in quarrying and working large masses of granite; they were familiar with the principles of mechanics, and with mechanical contrivances; and they had an almost unlimited command of human labour. An examination of Sir J. G. Wilkinson's 'Ancient Egypt and the Egyptians' would remove the difficulty, if we did not see by the examples afforded by a much less advanced people, the modern Indians, who by the simplest means first quarried and then removed and raised to its position the vast granite monolithic obelisk erected at Seringapatam in 1805, that with sufficient patient well-directed labour such tasks are accomplished with comparative ease. As to the removal of the obelisks—the proceedings of Belzoni, of the French in removing the Luxor obelisk, and especially those of Layard at Nineveh, are still more to the point. For descriptions of the methods adopted, it will be enough to refer to the authorities named below.

Assyrian Obelisks.—Among the remarkable discoveries made on the site or in the vicinity of the long-buried Nineveh, the finding of some monoliths resembling obelisks is not the least interesting. That now in the British Museum is the most important. It is a block of coarse black marble, 6 ft. 6 in. high, 2 ft. wide at the bottom, and 1 ft. 6 in. at top—where in the Egyptian obelisk the pyramidion would commence. The top in this instance, however, instead of sloping off to a point, as in the pyramidion of an Egyptian obelisk, diminishes by three steps, the termination being flat: Mr. Fergusson supposes this top to be a model of an Assyrian temple. As in the Egyptian obelisk, the sides of the shaft are narrower than the front and back. As a work of art, it is, both in design and execution, far inferior to the Egyptian obelisk; but as an historical monument it is of immense value. Each of the sides has five tires of bassi-rilievi, representing the king of Assyria receiving tribute from various conquered nations, consisting of prisoners, rare animals, vases, and other costly articles; and above, between, and below these are, in all, 210 lines of an inscription in cuneiform characters, which, as deciphered by Sir H. Rawlinson, was found to give an historical account of 31 years of the reign of Temenbar, ending about 885 B.C.

The very curious obelisk at Axum in Abyssinia, a granite monolith 60 feet high, but differing greatly in form from those of Egypt, is figured under AXUM, in the GEOG. DIV. There were once, it is said, more than 50 of these monoliths at Axum, of which four were equal in size to the one still standing. It stands on a base of three plinths; has rude sculptures, not hieroglyphics, on the sides; and is terminated with a round-topped patera. Its date is not ascertained; but it has been conjectured to be of Greek workmanship, and contemporaneous with a stone inscribed in rude Greek and, as Mr. Salt conjectures, Ethiopian characters, of about the year A.D. 300.

(Wilkinson, *Ancient Egyptians; Egyptian Antiquities,* in 'Lib. of Ent. Knowledge;' Hamilton, *Ægyptiaca;* Zoëga, *De usu et origine Obeliscorum;* Rossellini, *Monumenti dell'Egitto;* and the great work of the French government on Egypt; Layard, *Nineveh;* Bonomi, *Nineveh and its Palaces.*)

OBESITY is an excessive accumulation of fat in various parts of the body. It is not possible to define the boundary beyond which the fat in the body can be called excessive, for persons possessing it in the most varied degrees enjoy equally good health, and the same person may at different times possess more or less without any injury to his comfort. According to the calculations of Dr. Lankester ('Guide to the Food Collection,' South Kensington Museum) a human body weighing 154 pounds contains 12 pounds of fat. This quantity may be exceeded to a very large extent without producing obesity.

An excessive development of the adipose tissue may take place at any period of life. It is not uncommon in children; is far more rare in youth and in the early periods of manhood; and is most common after the age of 40, at which time an increase in the quantity of fat is observed in perhaps the majority of persons.

The chief accumulations of fat take place beneath the muscles, in the omentum and mesentery, about the heart, on the chest, and under the chin. In all these parts a certain quantity of fat naturally exists, and here therefore its amount is merely increased; but in cases of excessive obesity, it accumulates in situations where before there was none, as among the minute fibres of the muscles, even of the heart, and in various other tissues.

The accumulation of fat in the body produces a variety of effects. It is generally accompanied with an indisposition to exertion, and this at last so far prevents the growth of muscular tissue that stout persons become exceedingly feeble. This is also true of horses and oxen, which lose their capacity to labour as they become fat. Another evil attendant upon fatness is that the heart being taxed in proportion to the increased size of the body, becomes enfeebled, and local congestions and irregularities of the circulation are frequently the result. A proper expansion of the chest, and a free action of the abdominal muscles are also prevented, which lead to shortness of breath on slight exertion. Although persons may be stout and live to a good old age, yet their path is beset with danger, and their chances of life are not so great as amongst persons with a normal quantity of adipose tissue.

The causes of obesity are both natural and acquired. It is well known that among domesticated animals some have a greater tendency to accumulate fat than others, and such breeds are kept up for the purpose. In the same way there are human beings who exhibit the same tendency, and in the case of certain individuals the most persevering measures fail to reduce their weight. On what this tendency depends it is difficult to say exactly, but there is reason to believe that it depends upon the food in the early stages of digestion being converted into fat, which getting into the blood is deposited in the adipose tissue by a kind of excretory process. In such individuals the starch and sugar of the food appear to be more readily convertible into fat than in others. But whilst this tendency may naturally exist, it can be greatly increased by diet. There can be no doubt that the class of foods called carbonaceous,—starch, sugar, and fat—when taken in larger quantities than are required to maintain the heat of the body, are employed in developing the adipose tissue. Experiments on the feeding of animals have shown that in proportion as these substances are employed in the food do they become fat. Alcoholic beverages, when not taken to such an excess as to produce more disastrous results, have a tendency to produce fatness. They act in the first place by stimulating the digestive process, and in the next by preventing that action of the oxygen of the air on the blood and tissues by which the carbonaceous foods are oxygenated and carried off in the form of carbonic acid. Sedentary and indolent habits also have a tendency to produce fatness. As it is by active exertion that the oxygen of the atmosphere is introduced to the tissues of the body, and they are changed and carried away, so if this process be prevented by indolence, the tissues go on developing, and this is frequently the case with the adipose tissue. Heat has also a tendency to develope obesity. Living in warm rooms, or in a warm climate, other things being equal, has a tendency to produce fatness.

Whilst obesity is exposed to dangers of its own, a precipitate anxiety to keep it down or prevent it is most earnestly to be deprecated. The practice of taking vinegar to prevent obesity is attended with great danger, as it acts by destroying the digestive power of the stomach. Persons also frequently put themselves on a short diet, and without not only fat-forming matters but also flesh-forming matters in their food. In this way the heart soon breaks down for want of nourishment, and death occurs in a variety of ways from want of power in the central organ of the circulation. The entering also at once upon a system of hard exercise and short sleep is frequently attended with the death of the patient. The great object of treatment should be the gradual reduction of the fat, whilst the muscular power, especially of the heart, should be maintained. One of the most important things to be attended to is the nature of the diet. The amylaceous, saccharine, oleaginous, and alcoholic parts of the diet should be diminished. No butter at breakfast, no bread at dinner, and one glass of wine a day is a good receipt for a healthy fat man who has been in the habit of living indiscriminately. Hard biscuits may also be advantageously substituted for bread. Regular exercise should be taken, never excessive. Sawing, digging, walking and mountaineering according to the weight and strength of the patient are all good. Generally the obese are infirm of will, and this bodily state is perhaps connected with their mental condition, and of all patients they seem least able to make up their minds to the necessary discipline for their cure. If the persuasion implied in the sentence of "six months at the treadmill" could in any manner be applied in their case, it would undoubtedly be the most effectual remedy.

OBJECT-GLASS. The lens or system of lenses nearest the object in a telescope or microscope. As explained under EYE-PIECE, its business is to form a correct image of the object within the tube; hence it should be free from spherical aberration, and should be achromatic. For the method of rendering it so we must refer to MICROSCOPE, and for a due understanding of the defects, to ABERRATION in optics. [ACHROMATIC; LENS; LIGHT.]

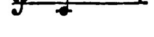
OBLATE, a term applied to a spheroid which is made by the revolution of an ellipse about the smaller of the two axes.

OBLIQUE. This term is used as opposed to direct or right, and signifies whatever is not direct or right. The word seldom appears, except as expressing that an angle is not a right angle, all other uses of it being almost obsolete.

OBLIQUITY, a term used in astronomy to express the angle made by the ecliptic with the equator. The greatest latitude at which the sun ever appears vertical is the obliquity of the ecliptic. [SUN; PRECESSION AND NUTATION.]

OBLONG, a word in common use, expressing the same meaning as, and in our opinion preferable to, the mathematical term rectangular, or having the figure of a rectangle.

OBOE (*Ital.*), a musical instrument of the pneumatic kind, blown through a reed: it is a tube of boxwood, 22 inches in length, slender in the upper part, but spreads out conically at the lower end, and consists of three joints, or pieces, besides the reed. Its compass is two octaves and a fifth, from C below the treble clef, to G, the fourth added line above it:—



Modern improvements have augmented the resources of the oboe by means of eleven keys, but only skilful performers can safely be trusted to produce the two or three highest notes; and till very recently, E, or even C, above the staff, was considered the utmost practicable extent of the instrument. Oboes are now frequently made to go down to B♭, in which case they exceed the usual length, and have an additional key.

The oboe has for centuries past been in use, and may be traced back to the reign of Edward III., in whose band oboes, under the denomination of *Wayghtes*, were employed. Indeed our itinerant parish-musicians, the official precursors of what was once a merry season, retain the appellation of *Waits*, though they have long abandoned the instruments which conferred on them their title.

Up to nearly the close of the last century, this instrument was only known, in most parts of Europe, by its French name, *Hautbois*, a word which in England has always been pronounced *Hoboy;* and this pronunciation has been transferred to the Italian term, though the word oboe is now invariably adopted in writing.

OBOLUS (ὀβολός), was a Greek coin, both silver and brass. At Athens it was of silver, the sixth part of a drachma, and worth somewhat more than five farthings sterling. The Æginetan obolus is stated to have been heavier than the Athenian. It is generally supposed that *óbolus* and *óbelos* (ὀβολὸς and ὀβελὸς) were originally the same word differently pronounced, and that the coin *obolus* was first of iron or copper, in form like a spit, which the word also means, or a bar; that a handful made a *drachme* (δραχμή); and that the form was afterwards changed from an oblong to a round shape, but that though struck round, like other money, it continued to retain the ancient name. Others say that the obolus was originally so called from being stamped with the figure of a skewer or spit, or other sharp-pointed instrument.

The Greeks had an hemi-obólion (ἡμιωβόλιον), or semiobolus, and a *trióbolon* (τριώβολον), or silver coin of three oboli, which was the common pay of the Dicastæ; the pay originally having been two oboli. Two *oboli* were placed in the mouth of a dead person, in order to enable him to pay for his passage over Styx. According to Lucian, Charon's demand was only one obolus. (Aristoph., 'Frogs,' 141; Lucian, 'Catapl.,' i., p. 643.)

According to Suidas (ὀβολός), the Athenian *obolus* contained six *chalci* (χαλκοῖ), and the *chalcus* contained seven *lepta* (λεπτά). Other authorities say that the *obolus* contained eight *chalci*. [NUMISMATICS.]

OBSERVANTS, or OBSERVANTINS. [FRANCISCANS.]

OBSERVATION AND EXPERIMENT. The first of these terms includes a portion of the second, inasmuch as every experiment is made with a view of observing the result. But experiment signifies more than observation, implying a disposition of means of observation which it is in the power of the experimenter to make for himself, and which he actually did make for himself. If, for example, a person who observed the attraction of the magnet for the first time, dubious of the residence of the attracting power, were to move the magnet to another place, that he might see whether the attracted body would still move towards it, he would make an experiment. But if his magnet were the sun and the attracted body the earth, he could only wait the proper times for observing the motion of the latter with respect to the former, in order to establish the attraction. Thus astronomy, geology, meteorology, natural history, &c., are sciences of observation (that is, of nothing but observation); while mechanics, optics, electricity, &c., are sciences of experiment. In one sense geology and meteorology are partly sciences of experiment, since portions of the material subject-matters of these sciences may be submitted to preconcerted tests. It would, however, be more proper to consider mineralogy and aero-mechanics as the experimental sciences connected with these, than to class them as mixed sciences.

To give an account of experiment would require us to explain the methods of every science which proceeds upon it: to give a detailed account of observation, we should need the description of all the means or instruments by which our senses are assisted in the examination of phenomena. We shall here confine ourselves to a short sketch of the errors which render observations discordant, and which make a final process of combination necessary in every case in which we cannot command results which agree with each other so well that the difference between them is imperceptible to the senses.

Everything which is called observation is of two kinds; in the first a simple individual fact is noted, in the second a magnitude is measured. The results of the first species are the proper subjects of inductive reasoning only; the results of the second, of inductive and mathematical reasoning, either or both. Individually, the first kind of observations are not necessarily subject to error; thus a zoologist observing the structure of a new animal might in every instance correctly note the resemblances which exist between it and other animals, and might refer it to its proper class in a manner which centuries of succeeding observation would not induce naturalists to disturb. Collectively, however, wrong inferences might be drawn from facts; thus results of classification which are true of all animals known up to one moment, and are therefore inferred to be always true, may be disturbed in the next moment by the discovery of a new specimen.

Observations of the mathematical character are of necessity erroneous from the imperfections of our senses. When a new insect is observed, it is soon seen, for instance, whether it has or has not wings, and the question once settled is finally settled. But when, say the specific gravity of a gaseous substance, at a given pressure and temperature, is *measured*, it is impossible to consider the question as settled at any time. Say that, under given circumstances, the specific gravity is asserted to be ·934 of that of air similarly circumstanced; this is only an admission, at most, of its being somewhere between ·9335 and ·9345. And that which we call an exact measurement of a length may for one purpose mean within a hundredth of an inch, for another within a thousandth, and so on; but no person dreams of having attained absolute truth. This being well known, and every process used in observation being subject to error, it is the business of the observer to repeat observations many times, and to extract a result as near to the truth as may be, from the mass of discordant materials which the repetition will furnish.

The necessary errors of observation arise from the imperfection of our perceptions and of the instruments which we use, and also from hasty or otherwise incorrect conclusions. The subject requires the separation of these errors into three classes, which may be mixed up with one another in results, and may be mistaken for one another. We may call them *fixed*, *personal*, and *casual*.

By a *fixed* error we mean one which is inherent in the instrument or method employed, so that it must exist, and, all other things remaining the same, must have a given magnitude. Thus, if the axis of an equatorial (supposing such an instrument to be employed for absolute measurements) do not absolutely coincide with that of the heavens, the right ascension and declination of a given star, measured when at a given distance from the meridian, must have a given error. It might be precisely the same in numerical effect, and would certainly produce an error of the same class if the observer used a wrong formula in the reduction of his observations. Thus, it would be perfectly possible to give to one observer an incorrect instrument and a correct formula, and to another a correct instrument and an incorrect formula, in such manner that their final results should coincide.

Errors of this kind cannot be detected by multiplying similar observations, since there can be no tendency to destroy error in the mere repetition of it. There are many modes of detecting fixed errors, and of allowing for them; but the only mode of avoiding them is by taking advantage of the construction of the instrument to use it for the same purpose under different circumstances, in such manner that measurements which are too large in one set of results must be as much too small in the other. If the same number of observations be contained in each set, this, as we shall presently see, is really a reduction of the fixed error to the class of casual ones; or rather, a destruction of the fixed error by the same process which gives the highest probability of destroying the casual errors.

All instruments must be more or less erroneous in every particular. In the science of observation, as now understood, and in any matter in which the utmost attainable exactness is requisite, the assumption of perfection in an instrument, in any point whatsoever, is looked upon as nothing but the expression of the observer's unwillingness to take trouble. For even if ninety-nine successive days' trials have shown that any particular error does not exist to any sensible amount, it is not conclusive against the observations of the hundredth day being affected by some new circumstance, necessary or accidental, in which the instrument has been placed in the intermediate time.

By a *personal* error is meant one of the same character as a fixed error, but arising from the temperament or habits of the observer, and not from the instrument. Thus if A should, in noting the time of a phenomenon by the clock, have a tendency to accelerate the moment of its happening, and B a similar tendency to retard it, the results of the two would differ by the sum of their personal errors. It has been discovered that two individuals, observing the same phenomenon with the same species of instruments may differ sensibly (though but little) from each other; and this not once or twice, but nearly always, and in such a manner as to make the average of a set of observations of one observer differ from that of the other. For anything we can know to the contrary, this species of error may exist in every observer; and its absolute quantity must be unknown until we can compare the observations of men subject to it with those of some other beings who are not. If indeed the personal error be purely casual, so that where one person measures too much, another measures as much too little, the average of the results of a large number of observers would give the truth or very near it. But should it be the case, which is not impossible, that all men are subject to an error of the same kind, some more and some less, namely, that all measure more or less too much, or else, that all measure more or less too little, the average above mentioned would give, not the truth, but the truth affected by the average error of all the observers. Nor would the results obtained ever enable us to distinguish whether personal errors have a fixed average or not; for suppose the fact observed to be that A, one time with another, measures more than B; this *may* mean either of several things:—either A measures truly, and B too little; or B measures truly, and A too much; or B measures too little, and A too much; or both measure too little, but B more than A; or both measure too much, but A more than B. Now, if A and B were to observe together for a century, the mere comparison of their observations, though it would settle their average amount of difference, would never enable us to give the least guess which of the preceding cases is the true one. If indeed we could convert the observer, as we have previously mentioned might generally be done with the instrument, into another observer with an error of the opposite kind, a true result, or one sensibly true, might be obtained. Suppose, for example, it is the observer's habit, in noting the transit of a star over a fixed wire in the field of a telescope, to take the transit too soon when the star comes in on the right side, and too late when on the left: consequently, by making a number of observations with an inverting telescope, and an equal number with one which does not invert, the average of both sets would be as likely to give a true result as if neither error had existed. [EQUATION, PERSONAL.]

All the errors which precede, though called errors because they give a result which is not the one intended to be obtained, yet are in fact the consequences of an actually existing state of things, and their laws can be determined by using the right means, or at least must be supposed to arise from natural causes measurable by experiment in the same manner as other consequences of existing relations. They are then really measures of phenomena, called errors simply because the effects of their causes are to be removed from the results. It is even possible that they might be made intentionally in a given form, with a view to prevent their occurrence in a more objectionable form. Thus, suppose an observer finds himself, in correcting discordant observations, apt to confound additions and subtractions, using one for the other: he will set his instrument intentionally wrong to an amount which casual discordances never reach, taking care, of course, to preserve means of correcting the intentional error with the rest; so that the requisite correction shall always be of one kind, additive or subtractive. Nevertheless this arrangement, as it should be called, would go by the name of an error, simply as being to have its effect afterwards destroyed.

By *casual* errors, the only ones to which the name of errors can properly be given, are meant those which are absolutely inexplicable, or of which the cause and tendency are equally unknown. They must be considered as equally likely to be positive or negative; so that in the long run the results which they give too great will be compensated by those which are too small. If this be not the case, that is, if there be a greater tendency to too much than to too little, there must be a reason for this phenomenon, and a law of action, which must be sought for and detected. Let us suppose this done, so that any result of a single observation, corrected for all discoverable sources of error, is in itself as likely to be too small as too great.

If all the observations be equally good, the MEAN, or average, is more likely to be true than anything else. This is even true with reference to fixed or personal errors which may remain, but which are totally unsuspected; for there is an even chance of such errors acting in either way. In the article just cited is shown the way of finding, from the observations themselves, the probable error, as it is called, or that which there is an even chance of not exceeding; with references to further sources of information. This article [MEAN], together with the general considerations in PROBABILITIES, THEORY OF, and WEIGHT OF OBSERVATIONS, will contain all we shall find it necessary to say on the subject.

It might be supposed that the greater the number of observations, the less, in the same proportion, the probable error of the average; but this is not true, since the probable error diminishes as the *square root* of the number of observations increases. Thus, suppose it to be well settled that twenty observations of a given observer will have an average of which it is an even chance that it does not err by (say) a unit: then the same observer must make *four* times as many observations to get an average with an even chance of not more than *half* a unit of error; *nine* times for one-*third* of a unit, and so on.

Those who neglect sound principles of observation are apt to overrate the effect of multiplying observations; which, though considerable, does not, as we see in the above rule, keep pace with the number of observations.

OBSERVATORIES, ASTRONOMICAL. We possess only an imperfect knowledge respecting the institutions established in ancient times for the observation of the heavenly bodies. The observatory of Alexandria is alone famous in the history of Greek astronomy. It was there that the observations were first made, upon which astronomy as a science, in the true sense of the term, was finally founded. With the revival of science in modern Europe, the establishment of observatories was soon felt to be indispensable to the progress of astronomy. The observatory of Tycho Brahé, erected in the island of Huena towards the close of the 16th century, under the auspices of Frederick III., king of Denmark, is memorable in the history of astronomy for having supplied the facts which enabled Kepler to destroy the epicyclical mechanism of the planetary movements, and to substitute in its stead the true theory of elliptical motion. About the same time William, Landgrave of Hesse Cassel, did good service to astronomy by the erection of an observatory, and the prosecution of a series of observations of the heavenly bodies. The lustre shed upon his country by the labours of Tycho Brahé doubtless acted as a powerful incentive in stimulating the Danish sovereigns to patronise astronomy. We accordingly find that the earliest national observatory of modern Europe was established in Denmark. The observatory of Copenhagen was commenced in 1637, but it was not completed until the year 1656. The first astronomer who was appointed to the direction of its labours was Longomontanus, the celebrated pupil of Tycho Brahé.

In the latter part of the 17th century a great impulse was given to practical astronomy by the invention of the micrometer, and the application of telescopic sights to the observation of the heavenly bodies. During this period the observatories of Greenwich and Paris were erected. We proceed to give a brief sketch of the history of the former of these institutions, although as regards priority of establishment the Paris Observatory has the advantage by a few years.

The Royal Observatory of Greenwich was established in the year 1675. The foundation stone of the building was laid on the 10th of August, and it was finished in less than twelvemonths afterwards. Flamsteed was appointed Astronomer Royal, with a salary of 100*l.* a-year. In the warrant of Charles II. for the payment of his salary, he is styled "our Astronomical Observator;" and he is directed "forthwith to apply himself with the most exact care and diligence to the rectifying the tables of the motions of the heavens, and the places of the fixed stars, so as to find out the so much desired longitude of places for the perfecting the art of navigation." Flamsteed took up his residence at the Observatory on the 10th of July, 1676, and shortly afterwards commenced his duties as an observer. In this capacity he continued to officiate till his death, which occurred towards the close of the year 1719. His observations are collected in an important work, entitled 'Historia Cœlestis Britannica,' published in three volumes folio; the third volume contains a catalogue of 2935 stars, reduced to the beginning of the year 1689.

The second director of the Greenwich Observatory was the celebrated Edmund Halley. His earliest observation is dated October 1, 1721. His labours were chiefly confined to observations of the moon. The results of these observations are inserted at the end of his planetary tables, published in 1749. No other observations made by this astronomer during his directorship of the Greenwich Observatory have been published. The original records of his labours are deposited in the Royal Observatory in four small quarto volumes. Upon the recommendation of Francis Baily, a copy of these observations was taken by order of the Lords Commissioners of the Admiralty, and presented to the Royal Astronomical Society in the year 1832. Halley died on the 14th of January, 1742.

Halley was succeeded in the office of Astronomer Royal by Bradley, who had already rendered his name for ever illustrious by his discovery of the aberration of light. In 1749, the Observatory having been furnished with a brass quadrant of eight feet radius, constructed by the celebrated artist, Bird, Bradley commenced a series of observations with the new instrument, which he continued to prosecute till shortly before his death in the year 1762. The results of his labours were subsequently published at the expense of the University of Oxford in two folio volumes, the first volume in 1798, under the superintendence of Dr. Hornsby, and the second in 1805, under the editorship of Dr. Robertson.

Bradley's observations of the stars have been reduced and discussed by the celebrated Bessel in a work published at Königsberg, in one volume folio, in the year 1818, entitled, 'Fundamenta Astronomiæ pro anno 1755, deducta ex observationibus viri incomparabilis James Bradley, in specula Astronomica Grenovicensi per annos 1750-62 institutis.'

Bradley is universally regarded as one of the greatest observers of ancient or modern times. The year 1750, when he commenced his labours with Bird's quadrant, may be considered as the epoch whence date observations comparable in precision with those of the present day. Henceforward the observations made at Greenwich have been employed almost exclusively in all the more important investigations of astronomy. Nor must we omit to state, that it was during his career as Astronomer Royal that Bradley made the series of observations, which resulted in his great discovery of the nutation of the earth's axis.

The successor of Bradley was Dr. Bliss, Savilian Professor of Geometry in the University of Oxford, who died in 1765. The next Astronomer Royal was the famous Dr. Maskelyne. His observations embraced the determination of the positions of the sun, moon, and planets, and a select number of stars; and he continued to adhere to this plan throughout the whole period of his career. Maskelyne first introduced the practice of observing the transit of a star at five vertical wires of the telescope. He was also the first who noted the transit of a star in terms of tenths of a second. His death occurred in the year 1811. The results of his observations have been published in four folio volumes.

Maskelyne was succeeded by Pond, who had already distinguished himself as a practical astronomer, having in the year 1806 communicated a paper to the Royal Society, in which he demonstrated that the brass quadrant of the Royal Observatory had undergone a change of form since its erection in Bradley's time. It was doubtless this circumstance which induced Maskelyne to solicit from the Government the construction of a mural circle of six feet diameter by Troughton, a request which was complied with; but the instrument was not quite finished at the time of his death. Soon after his accession to the office of Astronomer Royal, Pond commenced a series of observations with the mural circle, in the prosecution of which he evinced a high degree of talent. He first introduced the practice of observing a star by direct and reflected vision. The objects of his labours, besides the sun, moon, and planets, included also a considerable number of the stars. The observations in right ascension at the Royal Observatory, subsequently to the year 1816, were made with a new transit instrument of ten feet focal length, constructed by Troughton. In 1833, Pond published a catalogue of 1112 stars, which proved of great value to the practical astronomer. He retired from office in 1835, and died in the following year.

Pond was succeeded by Mr. Airy, who still continues to hold the office of Astronomer Royal. He had been previously Plumian Professor of Astronomy in the University of Cambridge, and had also been Director of the Cambridge Observatory since the year 1828. While engaged in the latter capacity he set the example of reducing all his observations as soon as they were made, a practice which has since been adopted at all public observatories. This eminent astronomer has signalised the period of his career at the Royal Observatory by numerous operations of great importance. Upon his recommendation, the Lords Commissioners of the Admiralty defrayed the expenses of reducing all the observations of the moon and planets made at Greenwich from 1750 to 1830. The results for the planets were published in 1846, in one quarto volume; those relating to the moon were given to the public in 1848, in two large quarto volumes. Several important catalogues of stars have emanated from the Royal Observatory during Mr. Airy's directorship. [ASTRONOMY.] In the instruments of the Observatory great improvements have also been effected. In 1847 an altitude and azimuth circle of a peculiar construction (termed an altazimuth) was erected, for the special purpose of making observations of the moon out of the meridian. In 1851 a powerful transit circle was erected, and henceforward all observations, both of right ascension and polar distance, were made with the same instrument. In 1852, an instrument termed the reflex zenith tube was erected, the object of which is to make observations near the zenith, mainly for the purpose of determining the value of aberration. In 1853 the American method of recording transits of stars by electro-magnetism was introduced at Greenwich. In 1859, observations were commenced with a magnificent equatorially mounted refractor of 12 inches aperture. It may be remarked, finally, in connection with this brief sketch of the Royal Observatory, that a great number of chronometers for the Admiralty are being constantly rated at the same establishment.

The other public observatories of the British Isles are those of Oxford, Cambridge, Portsmouth, Durham, Liverpool, Edinburgh, Glasgow, Dublin, and Armagh. Of private observatories may be mentioned the following:—The observatory of Mr. Bishop, Regent's Park; the observatory of Mr. Warren De La Rue, Cranford, Middlesex; the observatory of Mr. Carrington, Redhill; the observatory of Mr. Whitbread, at Cardington, in Bedfordshire; the observatory of Dr. Lee, at Hartwell; the observatory of Lord Wrottesley, at Wrottesley Hall; the observatory of Mr. Lassell, at Bradstones, near Liverpool; and the observatory of the Earl of Rosse, at Birr Castle, Ireland.

The Royal Observatory of Paris was commenced in the year 1667, but was not completed until 1671. Its early history was illustrated by the labours of Dominique Cassini and Picard. M. Le Verrier, one of the independent discoverers of the planet Neptune, is the present director of that establishment. The only other public observatories of France are those of Marseille and Toulouse.

Perhaps no country in Europe is so richly endowed with public observatories as Germany. In the north of Germany we find the observatories of Berlin, Königsberg, Breslau, Bonn, Göttingen, Gotha, and Hamburg; in the south there are the observatories of Vienna and Munich. The observatory of Königsberg is celebrated for having been the scene of the labours of the illustrious Bessel.

In Italy there are numerous public observatories, of which the most famous is the observatory of the Collegio Romano, Rome, directed by the distinguished astronomer, Professor Secchi.

In Russia great efforts have been made during the present century to promote the cultivation of astronomy. The Imperial Observatory of Pulkowa, directed by the celebrated astronomer M. Struve, is perhaps the most magnificent institution that has ever been established for the advancement of practical astronony. There is also in Russia the observatory of Dorpat, directed by Professor Mädler; and the observatory of Moscow, of which Professor Schweizer is director.

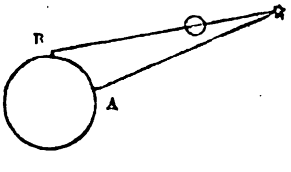
Observatories have been established throughout the other countries of Europe. A list of these establishments is given in the article ASTRONOMY.

In the United States of America great progress has been made during the last quarter of a century, in the cultivation of practical astronomy, and a number of flourishing observatories are now in active operation. Of these the most celebrated are the National Observatory, Washington, and the Observatory of Harvard College, Cambridge, Massachusetts.

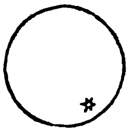
OBTUSE, opposed to acute, is applied to an angle which is greater than one right angle and less than two.

OCCULTATION. This word, which might serve to design any eclipse of one heavenly body by another, and even the effect of cloud or fog, is particularly applied to the eclipse of a fixed star by the moon. It has been seen [MOON] that the spiral course of the moon's real orbit must bring her at some time or other in the course of a revolution of the nodes (18½ years) at or near to every star situated within about 5° of the ecliptic either way. There are consequently continual occultations of stars by the moon; such of which as can be made useful in finding the longitude are given yearly in the 'Nautical Almanac.'

If the moon were (like the star) so distant that two spectators at nearly opposite points of the earth would not be sensibly removed from each other in space when their distance from each other was compared with their common distance from the moon, then all observers, wheresoever situated, would see the moon begin to hide a star at the same instant. They would all then be able to note by their different clocks the absolute instant of the same phenomenon; and [LONGITUDE] their differences of clock-time at this absolute instant would give their differences of longitude. But the proximity of the moon makes it possible that one observer (at A) may see no occultation at the time when such a phenomenon has occurred to another (at B); and makes it certain that two observers cannot see the beginning of an occultation at the same instant of absolute time. Both therefore must deduce from their own observed times of commencement, and from their knowledge of the moon's place and motions, the times, at their several places, at which a spectator situated at the earth's centre would see the star touch the moon's limb; and this being done, they are in the same position as if the moon had been too distant to require such a process. If, in this work, we had given the details of astronomical calculations, we should not have separated that required in reducing an occultation to the earth's centre from the similar case which occurs in an eclipse of the sun or a transit of Venus: the principles employed in all are identical, though the first process is rendered more simple than the second or third, by the very great distance of the star, which may be considered as marking the same point of the heavens at all places. For the value of observed occultations in finding the longitude, see the article LONGITUDE.



Here we might close this article, if it were not for a singular circumstance which sometimes occurs; and which cannot be traced either to the character of the telescope employed, of the observer, of the weather during the observation, or of the particular star under occultation. When the moon approaches the star, instead of an instant of contact, followed by disappearance of the star, the latter for a few seconds is frequently thrown upon the moon, as if it were the nearer body, and were going to cross the moon's surface, as Venus does that of the sun during a transit. While this is taking place, which sometimes lasts until the star has fairly left the moon's limb or border, the star preserves its light, though it frequently undergoes a change of colour. Aldebaran, whose natural colour is inclining to red, has been seen to present this phenomenon much more frequently than any other star: but θ Tauri, θ^1 and θ^2 Pleiadum, Spica Virginis, Regulus, γ Libræ, 132 Tauri, α^1 Cancri, 49 Libræ, λ Aquarii, 249 Aquarii, 187 Sagittarii, γ Tauri, ρ Leonis, ρ Geminorum, δ Cancri, δ Piscium, &c., have been seen more or less to come upon the moon's limb. See a detailed list of quotations from the different observers in a paper by Mr. South, On the Occultation of δ Piscium by the Moon,' in the third volume of the 'Memoirs of the Astronomical Society.' It is to be noted that many of these appearances did not exhibit the whole of the phenomenon, but made the star hang for some seconds upon the moon's limb, instead of immediately disappearing.



The occultations of Aldebaran approaching again in the years 1829 and 1830, the Society just mentioned invited the particular attention of astronomers to them. The consequence was, a large number of communications from different parts of Europe, which are printed in the fourth volume of their Memoirs. Nothing can be more different than the results: some, now saw the phenomenon for the first time; others, who had seen it before, did not see it; some, who had never seen it before, continued unable to do so. Of six observers at the Royal Observatory, five distinctly saw the projection on the moon's limb, and one saw it hang on the edge of the moon five or six seconds before it disappeared. Of three at the Observatory of Paris, two distinctly saw the projection, and one saw the star disappear instantaneously, leaving a shade ("ombre") on the part of the moon at which it disappeared. The majority saw the star either projected or hanging on the moon's edge. It is to be noted that this phenomenon has been seen at the dark edge of the moon as well as at the enlightened. Its cause is matter of much diversity of opinion.

The most recent explanation is due to Mr. Airy, who in the year 1859 communicated a paper on the subject to the Royal Astronomical Society, which is to be found in the twenty-eighth volume of the 'Memoirs' published by that body. Mr. Airy remarks, "that on the principles of the undulatory theory of light, the image in a telescope of any luminous point, whether a star or a portion of the moon's illuminated surface, is not a point." This is exemplified in the case of the bright rings which surround the image of a star as seen in a good telescope. It is plain also, for the same reason, that the aggregate of light produced by the aggregate of all the luminous points of the moon's disc, is not a luminous image bounded by a sharp outline, at what we consider the geometrical outline of the image, but that the geometrical outline is fringed by a band of illumination, produced by the interlacing and superposition of all the systems of rings. Hence it follows that when, with a very fine telescope we see the moon's limb very sharply defined, and apparently surrounded by immediate darkness, we do in reality see it erroneously. Mr. Airy conceives that during ordinary observations of the moon, the conviction that the outline of light ought to correspond to a given curve, may affect the visual organs so as to incapacitate them from perceiving the fainter light beyond that curve; but that in the excitement and intentness of observing an occultation, the state of the sensational organisation is probably much changed, and as the presumed time of the phenomenon comes nearer and nearer, the eye probably becomes more and more sensible to the faint diffused light, and the visible boundary of light extends further and further into the darkness. In numerous instances when the boundary of the moon's light has swelled till it touches the star, it swells no further, and the star hangs on the moon's limb. According to Mr. Airy, it seems perfectly conceivable, that the mental contemplation of the relation of the positions of the moon and star which is implied in the phenomenon that is to be observed, may frequently so far act on the sensibilities, that when that relation (namely, contact) is once gained, the mental effort does not make the sense more acute than is necessary, and may even somewhat relax as the denser light of the moon reaches the star. This explanation, it will be seen, refers the phenomenon to the principle of the irradiation of light.

OCCUPANCY. This term in English law signifies the taking possession by any person of any thing which has no owner (Bracton, fol. 8, *b*), and the general doctrine, as stated in Bracton, is derived from the *Jus Gentium* of the Roman lawyers, as explained in the 'Digest' (lib. 41, tit. 1, s. 1, 3, 5, &c.). That use of the term which will be here explained has reference to the occupation of land.

An estate *pur auter vie*, or for the life of another person or persons, had formerly some peculiar qualities incident to it. If a man had an estate in land for his own life, such estate was of course determined by his death. But if he had an estate in land for the life of another person, and he or his assignee died before such person, the estate was not determined, and yet there was nobody to take it, inasmuch as it could not go to the heir, nor, being a freehold interest, to the executor or administrator. Such an estate belonged to the first person who could take possession of it, and he was entitled to hold it as general occupant till the expiration of the life for which it was originally granted. But if the original grant were to A and his heirs, for the life of B, and A died during the life of B, the heir of A took the estate as special occupant—that is, as a person designated in the original grant. Sometimes the heir was said to take the estate as a descendible freehold, though the estate is admitted not to be an estate of inheritance, and therefore not subject to courtesy or dower,—it not being perceived that to say an estate is not an estate of inheritance and yet is descendible, is a contradiction, for descent implies an heir who takes as heir. Still it appears from Bracton (fol. 26 *b*, 62 *b*), that if lands were given to a man and his heirs for the life of another person, the heir could recover the land by an assise of *mort d'ancestor*, because the ancestor died seised as of fee, and a man could claim by an assise of *mort d'ancestor* any land of which his ancestor was seised as of a fee (*ut de feodo*); and hence it has been concluded that the heir took not as special occupant, but that he took a descendible freehold. This subject of occupancy, general and special, is discussed at great length and with considerable acuteness by Vaughan, Justice. (Vaughan, Holden *v.* Smallbrooke.)

In the case of copyhold, when there was no special occupant, the lord took the estate; for the lord, having the freehold, was also considered to have the possession; and therefore "vacancy," the necessary condition to any other person's title by occupation, was wanting. In the case of a rent or other incorporeal hereditament, when there was no special occupant, inasmuch as there could be no entry, there could of course be no possession or title by general occupancy.

It is stated by Bracton, that if land was given to a man for the life of another without any mention of his heirs, the land on the death of the donee did not immediately revert to the donor, unless the donee died intestate, or unless, though he made a will, he had made no mention of his interest in the land as of a term of years, but that if he had disposed of it in his will as of a chattel, such disposition was valid. (Bracton, fol. 27 *a*; see Doe dem. Blake, 6 T. R., 291.) This power of disposing of a freehold interest in land must have fallen into disuse after the time of Bracton; for it is quite inconsistent with the doctrine of general occupancy as stated by Littleton, and also with the general rule of law, which prevented freehold interests in land from being disposed of by will, before the Statutes of Wills passed in the reign of Henry VIII. But the Statutes of Wills were limited to estates in fee simple, and no power to devise estates *pur auter vie* existed at law before it was given by the Statute of Frauds.

Since the passing of the Statute of Frauds (29 Car. II. c. 3), general occupancy (with, perhaps, one exception, hereafter mentioned) has ceased to exist. By that statute (s. 12) a man was enabled to devise an estate *pur auter vie* by a will in writing, executed as therein mentioned, and attested by three witnesses; and if no such devise thereof was made, the estate was chargeable in the hands of the heir, if it should come to him by reason of a special occupancy, as assets by descent, as in case of lands in fee-simple; and in case there should be no special occupant thereof, it was declared that it should go to the executors or administrators of the party that had the estate thereof by virtue of the grant, and should be assets in their hands—that is, should be liable to the payment of the testator's or intestate's debts. By the 14 Geo. II. c. 20, s. 9, which recites "that doubts had arisen, where no devise had been made of such estates, to whom the surplus of such estates, after the debts of such deceased owners thereof were fully satisfied, should belong:" it was enacted, "That such estates, *pur auter vie*, in case there was no special occupant thereof, of which no devise should have been made according to the said Act (29 Car. II. c. 3), or so much thereof as should not have been devised, should go, be applied, and distributed, in the same manner as the personal estate of the testator or intestate." These two statutes provided for the case both of a devise being made of an estate *pur auter vie*, and also for the case of the land coming to the heir as special occupant where no devise was made. But an estate *pur auter vie* may be limited either to a man and his heirs, or to a man, his executors and administrators, or to a man simply without mentioning either heirs, executors, or administrators. The Statute of Frauds appears to contemplate the heir only as special occupant, and if there was no devise according to the statute, and no special occupant, which would happen when the estate was limited simply to the grantee, the estate went to the executor or administrator for the payment of debts, and after payment of debts the surplus was distributed, under the act of George II., in the same manner as the testator had directed the distribution of his personal estate, or it went, in case of an intestacy, to the next of kin of the intestate. But when no devise was made according to the statute, and the estate was limited to the grantee, his executors and administrators, inasmuch as the heir could not in that case be special occupant, the question arose, if the executor or administrator could be such occupant, and if he could, the further question arise, who was to have the estate after payment of debts? The proper construction of the two statutes seemed to be that the heir only could be special occupant, and that he alone could take as such. If, then, the land were not devised according to the Statute of Frauds, and there was no special occupant, by reason of the limitation being simply to the grantee, or to him, his executors, and administrators, the executor or administrator would take it under the Statute of Frauds, and distribute it, after payment of debts, under the statute of George II. The executor or administrator took the estate as a freehold, which it is, but in trust for the persons entitled under a will, which was sufficient to pass personal estate, or, in cases of intestacy, in trust for the next of kin. (See the opinions of Lord Redesdale, in Campbell *v.* Sandys, 1 Sch. and Lef., 288; and the opinions of Lord Eldon, in Ripley *v.* Waterworth, 7 Ve., 425.)

If a man dies intestate who is seised of an estate for another's life, and the limitation is such that the estate cannot go to his heir as special occupant, the estate seems open to a general occupancy until an administrator is appointed: but such administrator seems to have a title by relation.

Neither the Statute of Frauds nor that of George II. applied to copyholds, and therefore not to estates *pur auter vie* in copyhold lands.

Estates *pur auter vie*, whether there shall or shall not be any special occupant thereof, and whether the same shall be freehold, customary freehold, tenant right, customary or copyhold, or of any other tenure, and whether the same shall be a corporeal or incorporeal hereditament, are now devisable by a will in writing executed in the manner prescribed by the statute of 1 Vic. c. 26, which repeals, among other clauses, that part of the Statute of Frauds which relates to estates *pur auter vie*, and also the 9th section of 14 Geo. II. c. 20. And if no disposition by will is made of any estate *pur auter vie* of a freehold nature, the same shall be chargeable in the hands of the heir, if it shall come to him by reason of special occupancy, as assets by descent, as in the case of freehold land in fee simple; and in case there shall be no special occupant of any estate *pur auter vie*, it shall go to the executor or administrator; and if the same shall come to the executor or administrator either by reason of a special occupancy or by virtue of that Act, it shall be assets in his hands, and shall go and be applied and distributed in the same manner as the personal estate of the testator or intestate. This statute settles a number of questions, some of which have been already referred to, which were of frequent occurrence, with respect to estates *pur auter vie*.

On the subject of occupancy, the reader may consult Puffendorf, 'Law of Nature and Nations,' iv., c. 6.

OCCUPATIONS OF THE PEOPLE. [Census.]

OCEAN. [Sea.]

OCHRE. Certain impure oxides of iron, of a yellow, red, or brown colour, are employed as pigments, under the name of ochres. They generally contain clay. [Colouring Matters.]

OCTAGON. [Polygons, Regular.]

OCTAHEDRON. [Solids, Regular.]

OCTANS (the instrument commonly called a quadrant, which, when on Hadley's construction, is of the form of an *octant*, or eighth part of a circle), a constellation of Lacaille, situated at the south pole, which it includes. There are no stars of conspicuous brightness in this constellation.

OCTAVE (*Octavus*, Lat.), in Music, the eighth note of the scale the most perfect of concords, whose ratio is 2 : 1, therefore the simplest of all the sounds, except the unison. The harmonics of the octave and unison agree invariably, a coincidence which occurs in no other interval, and these sounds have so close a resemblance, that in combination they are hardly distinguishable the one from the other. The following are the properties, says Rousseau, which so singularly distinguish the octave from all other intervals:—The Octave embraces all the primitive sounds, that is to say, all the original tones and semitones. Hence, after having established a system or series of notes within the limits of an octave, if it be wished to extend this series it will be absolutely necessary to follow the same order in a second octave, in a third, or a fourth, &c., and no sound will be found in any of these but what is, as it were, a recurrence of some one in the first series. It is in virtue of this property in the Octave that the term *Diapason* was applied to it by the Greeks. [Diapason.]

The Octave has also another remarkable property, the same writer observes, namely, that it may be doubled, tripled, and multiplied at pleasure, without changing its nature. This multiplication, however, is limited as relates to its effect on the ear, and an interval of eight octaves, for instance, would be scarcely, if at all, appreciable as such by the auditory organ. A double Octave is less agreeable than a single one; a triple Octave loses still more of its pleasing quality; till, by increasing the distance, the relationship of the sounds becomes nearly undistinguishable.

OCTAVE FLUTE. [Flute.]

OCTOBER, in the year of Romulus, was strictly what its name implies, the eighth month. With us it is the tenth. Suetonius tells us that Domitian, who was born in this month, gave it his own name (Sueton., 'Domit.,' c. 13); but it lasted during his life only (Plutarch, 'Num.,' p. 72; Macrobii, 'Saturnal.,' i. 12). Antoninus Pius, in honour of his wife Faustina, called it "Faustinus" (Julius Capitolinus, c. 10); and the flatterers of Commodus assigned to it one of their patron's epithets, "Invictus." (Ælius Lamprid., ed. Lugd. Bat., 1671, p. 507.) Our Anglo-Saxon ancestors gave it the name of *Winter-fylleth*, the winter full-moon, or winter-beginning, as they reckoned by winters not by years. They also called it *teotha monath*, the tenth month. (Bosworth, 'Sax. Dict.')

OCTYL. [Caprylic Alcohol; *Capryl.*]

OCTYLAMINE. Synonymous with caprylamine. [Caprylic Alcohol.]

OCTYL-CUMINAMIDE $\left(N\left\{\begin{array}{l}C_{20}H_{11}O_2\\ C_{16}H_{17}\\ \;\;H\end{array}\right.\right)$. An amide formed by the action of chloride of cumyl upon octylamine. [Amides.]

OCTYLENE. [Caprylic Alcohol.]

OCTYLIC ALCOHOL. [Caprylic Alcohol.]

OCTYL-PHOSPHORIC ACID. When octylic alcohol is placed in contact with vitreous phosphoric acid, it forms an acid similar to ethyl-phosphoric acid, and to which the name octyl-phosphoric acid has been given.

OCTYL-SULPHURIC ACID; *Sulphoctylic acid.* Synonymous with sulpho-caprylic acid. [Caprylic Alcohol.]

OCULAR IMAGE. [Eye, in Nat. Hist. Div.]

OCULAR SPECTRA. [Accidental Colours.]

ODE is derived from a Greek word, which signifies a song (ᾠδή, ἀοιδή), and appears to have been originally applied to any kind of poetry which was written to be sung or accompanied with music. The ode may be regarded as the foundation of lyric poetry, and differs from epic poetry in delineating the poet's own thoughts and feelings, while the latter species of poetry details external circumstances and events. The most celebrated Greek and Roman odes are those of Pindar, Horace, and Anacreon. In English the best odes have perhaps been written by Dryden and Gray. For a further account of this species of poetry the reader is referred to Lyric Poetry.

ODIN. [Scandinavian Mythology.]

ODO'METER (from ὁδός, a road, and μέτρον, a measure) is an instrument used for measuring the distances passed over in travelling, and is very nearly the same as that which is called a pedometer: the latter is carried in the pocket of a person on foot or on horseback, and the former is attached to a carriage. Grayson's odometer is a box containing a train of wheel-work, and is attached to one side of a carriage above the axle. There are two dials, one for the driver and the passengers, the other for the proprietor: the object of the apparatus being to record the distance run, as a check upon the honesty of the driver of any hired vehicle. The apparatus belongs to one of the classes or groups described under Numbering Machines.

ODORINE. [Picoline.]

ŒCUMENICAL COUNCILS. [Council, of the Church.]

ŒNANTHIC ACID ($HO, C_{14}H_{13}O_2$). This acid, in combination with oxide of ethyl forming *œnanthic ether* ($C_4H_5O, C_{14}H_{13}O_2$), is found in grape wine, and gives to that liquid its characteristic odour. The ether is obtained on distilling wine itself, or wine lees with water; it is then decomposed with caustic potash, and the œnanthate of potash distilled with sulphuric acid, when œnanthic acid passes over, and condenses at 56° Fahr. into a semi-solid colourless fat, of the consistence of butter. At a higher temperature it melts, is inodorous and tasteless, reddens litmus paper, and easily dissolves in the caustic alkalies, alkaline carbonates, ether, or alcohol. Heat splits œnanthic acid up into water and anhydrous acid; but in other respects it greatly resembles pelargonic acid. M. Fischer has just (1860) announced his belief that the so-called œnanthic acid is merely a mixture of capric and caprylic acids.

ŒNANTHOL, *œnanthylic aldehyd*, or *hydride of œnanthyl* ($C_{14}H_{14}O_2 = C_{14}H_{13}O_2, H$). This substance forms about ten per cent of the products of the destructive distillation of castor oil. It may be purified by agitation with baryta water and re-distillation, and finally obtained dry by digestion over chloride of calcium.

Œnanthol is a colourless liquid, of sp. gr. 0·8271 at 63° Fahr. Its boiling point is 312° Fahr., and vapour density 4·17. It has a penetrating odour, and at first sweet, but afterwards acrid taste. It is soluble in alcohol or ether, but very slightly so in water. It forms a crystalline compound with bisulphite of soda, and is converted into œnanthylic acid by nitric acid, chromic acid, or even by exposure to air.

Metœnanthol is a crystalline body, isomeric with œnanthol. It is produced when œnanthol at 32° Fahr. is mixed with nitric acid at the same temperature, and the whole set aside for twenty-four hours.

Hydride of trichlorœnanthyl ($C_{14}H_{11}Cl_3O_2$) is a heavy oily fluid, resulting from the action of chlorine upon œnanthol.

ŒNANTHYLAMIDE. [ŒNANTHYLIC ACID.]

ŒNANTHYLIC ACID ($HO, C_{14}H_{13}O_3$). This acid is a frequent product of the oxidation of fatty matters by nitric acid. It is most conveniently prepared by heating castor oil with twice its bulk of nitric acid; red fumes are evolved in great abundance at first, but afterwards more moderately, until, at the end of a few hours, the action is complete, and the acid then rises to the surface as an oily layer. It may be rectified with water, and finally dried over anhydrous phosphoric acid.

Œnanthylic acid is a colourless, transparent oil, of agreeable aromatic odour and acrid taste. It is only slightly soluble in water, but readily so in alcohol, ether, or nitric acid. It boils at 298° Fahr., and may be distilled, but suffers partial decomposition during the operation. It does not become solid at 0°. Ignited, it burns with a clear non-smoky flame.

The *œnanthylates* are easily formed by dissolving carbonates in œnanthylic acid. The *potash salt* does not crystallise, but furnishes *anhydrous œnanthylic acid* ($C_{14}H_{13}O_{13}, C_{14}H_{13}O_{13}$) on distilling with oxychloride of phosphorus. *Œnanthylate of copper* crystallises in beautiful green needles, soluble in alcohol, and slightly so in water. *Œnanthylate of baryta* ($BaO, C_{14}H_{13}O_3$) occurs in lamellar crystals. *Œnanthylate of ethyl*, or *œnanthylic ether*, contains ($C_4H_5O, C_{14}H_{13}O_3$).

Œnanthylamide ($NH_2(C_{14}H_{13}O_2)$) is produced by the reaction of œnanthylic acid and ammonia. It crystallises from alcohol in little plates.

ŒNANTHYLO-BENZOIC ANHYDRIDE $\left(\left.\begin{matrix}C_{14}H_{13}O_2\\C_{14}H_5\,O_2\end{matrix}\right\}O_2\right)$. [ANHYDRIDES.]

ŒNANTHYLO-CUMINIC ANHYDRIDE. [ANHYDRIDES, *Cumino-œnanthylic.*]

OTHYL. Synonymous with acetyl. In addition to the compounds of this negative radical alluded to under ACETYL, it may be here mentioned that bromal is regarded as a compound of othyl; its composition is analogous to that of chloral, the chlorine of the latter being replaced by bromine. The following is a list of other compounds of othyl.

Hydride of othyl or aldehyde	$\left.\begin{matrix}C_4H_3O_2\\H\end{matrix}\right\}$
Aldehydide of ammonium	$\left.\begin{matrix}C_4H_3O_2\\NH_4\end{matrix}\right\}$
Potassium aldehyde	$\left.\begin{matrix}C_4H_3O_2\\K\end{matrix}\right\}$

OTHYL, HYDRIDE OF. [OTHYL.]

OFFERINGS, OBLATIONS, and OBVENTIONS, are not only those small customary sums paid at Easter, but also the customary payments for marriages, christenings, churchings, and burials. By 2 & 3 Ed. VI. c. 13, "all persons which by the laws and customs ought to make or pay their offerings, shall yearly well and truly content and pay the same to the parson, vicar, proprietor, or their deputies or farmers, of the parishes where they shall dwell or abide; and that at such four offering-days as at any time heretofore within the space of four years last past hath been used and accustomed for the payment of the same; and, in default thereof, to pay for the said offerings at Easter then next following." The four offering days above spoken of were Christmas, Easter, Whitsuntide, and the feast of the dedication of the parish church. It is directed by the rubric, at the end of the Communion Service, that "yearly at Easter, every parishioner shall reckon with the parson, vicar, or curate, or his or their deputy or deputies, and pay to them or him all ecclesiastical duties accustomably due then at that time to be paid." Easter offerings are due of common right, as well as by custom. (Bunb. 173, 198.) Thus, in Carthew *v.* Edwards, Trin. 1749, in the Exchequer, it was held that Easter offerings were due of common right, after the rate of 2*d.* a-head for every person in the family of sixteen years of age and upwards. But by custom the sum may be more. In London 4*d.* a-head is usually claimed.

Surplice-fees are payable for every marriage, whether by banns or licence; and for every funeral, churching, or christening, according to the custom of the parish. Mortuaries are claimed on the death of each person in a parish, according to value of property left, but not to a greater amount than 10*s.*

(Burn, *Ecclesiastical Law*; Blackst., *Comm.*, Mr. Kerr's ed. vol. iii., c. 7.)

OFFICE FOUND. By the common law of England, where the crown is entitled, upon the occurrence of certain events, to take possession of real or personal property previously belonging to a subject, the facts upon which the right accrues must be first ascertained by an inquisition or inquest of office. This inquiry is executed by some officer of the crown, such as the escheator, coroner, or sheriff, or by persons specially commissioned for the purpose, and the facts are ascertained by a jury of an indeterminate number, but consisting usually, though not necessarily, of twelve men. Such inquests were much more frequent before the abolition of military tenures, when inquisitions *post mortem* were instituted upon the death of any of the tenants of the crown, to inquire of what lands he died possessed, and of other matters tending to establish the right of the lord respecting the property of the deceased. [JURY.] When an inquisition of this kind has been executed and returned, it is said to be *an office found.* Thus where treasure has been discovered under circumstances which do not give it to the owner of the land, an inquest is held, and the crown, upon office found, takes it; and where a person of illegitimate birth dies intestate, the sovereign (if he is the immediate lord of the fee), upon office found, is entitled to all his land: in the latter case however the land is generally granted again to some person or persons who can make out the most reasonable claim to it. So also the verdict of a jury upon a coroner's inquest, declaring a person to have died *ut felo de se*, is an office found, upon which the crown becomes entitled to take possession of the property of the deceased.

OFFICE, HOLY (*Sanctum Officium*). [INQUISITION.]

OFFSETS are lines drawn perpendicular to the chord of an arc, or the longest base of an irregular polygon, from points in the arc, or corners of the polygon. By means of these offsets the area contained between the chord and arc can be found with sufficient nearness. We mention this well-known term of surveying to direct attention to the article QUADRATURES, METHOD OF, which contains the set of successive approximations of which the surveyor's process is the first and rudest step.

OIL COLOURS. [PAINTING, HOUSE.]

OIL OF TURPENTINE. [TURPENTINE.]

OIL OF VITRIOL. [SULPHUR; *Sulphuric Acid.*]

OIL PAINTING. [PAINTING.]

OILS, MANUFACTURE OF. The manufacture of animal oils, such as that of the whale, is simple. The *blubber*, or fat from which the oil is procured, is usually cut into small pieces and packed in casks soon after it is taken from the whale; it is then brought home in a half-putrid state, and is emptied into a large wooden vessel or receiver, capable of holding several tons. From this receiver the decomposing fat is conducted, after settling for a few hours, into a copper boiler, in which the separation of the fluid from the solid portions of the blubber is completed by the application of heat. From the boiler the oil flows through a kind of filter of brushwood, which detains the grosser impurities, into coolers, from which, when quite cold, it may be drawn off into casks. Various chemical processes are employed for purifying whale oil and diminishing its unpleasant smell. The quantity of oil obtained is about four-fifths that of the blubber used. In the South-Sea fishery it is found advisable to boil the blubber on board the whaling vessels, and to bring home the oil in the liquid state in casks. In this process, as commonly performed, the oil is very imperfectly extracted from the blubber, and the *scraps*, or solid portions which remain, are used as fuel under the *try-pots*, or boilers; by which arrangement the oil that remains in them is not only destroyed, but the substance becomes, from its great inflammability, a source of serious danger. To obviate these evils some ships are provided with powerful screw-presses for squeezing out whatever oil may remain after the process of boiling the blubber, and thus materially increasing the produce. Hebert, in the 'Engineer's and Mechanic's Encyclopædia,' gives an engraving and description of such a press; in which the blubber-scraps, while yet warm, are put into a hollow cylinder, and compressed by a piston brought down upon them with a great force. The oil escapes through holes in the bottom of the cylinder, between which and the blubber is laid a mattress of wicker-work, to prevent the blubber from choking up the holes. This press is the invention of Mr. John Blythe, of Limehouse.

Olive oil differs from most vegetable expressed oils in being extracted from the soft fleshy pericarp; whereas such oils are usually procured from the seeds only. The manufacture is simple, and is usually conducted with very rude machinery. In the neighbourhood of Aix, in Provence, the first and finest oil is obtained by crushing the olives in a kind of mill, in which the crushing-stones are so mounted as not to break the stones of the fruit, but simply to crush the pulp. The mass thus bruised is put into *cabas*, or bags made of bulrush-matting, or of coarse canvas, which are piled or laid upon one another to the number of about a score, and exposed to gradual compression in a screw-press; the oil which flows from the cabas, which is the pure virgin oil, is conducted by channels into casks or stone cisterns partly filled with water, on the surface of which it floats so that it may be readily collected by skimming. When the oil ceases to flow, the mass of pulp is taken out of the bags, mixed with boiling water, and treated as before, but with an increase of pressure. The second quality of oil thus procured is quite fit for table use when fresh, but is apt to become rancid by keeping. After skimming off the oil which accumulates on the surface, the subjacent water still retains a good deal of oil, by the intervention of the mucilage; but after long repose in a large cistern the oil and water separate, and the water may be drawn off from below. This oil, however, is of very inferior quality, and can only be used for factory purposes. A still coarser kind of oil is finally procured by crushing the marc, or solid residue, in a mill, so as to break the stones, boiling it with water, and re-pressing it. All the oil must be *fined* by keeping in clean tuns, in an apartment heated to at least 60° Fahr., for twenty days; after which it is run off into strong casks, cooled in a cellar, and then sent into the market.

Olive oil is refined, for the use of watchmakers, in the following way. Into a bottle or phial containing the oil, a slip of sheet-lead is immersed, and the bottle is placed at a window, where it may receive the rays of the sun. The oil by degrees gets covered with a curdy mass, which after some time settles to the bottom, while itself becomes limpid and colourless. As soon as the lead ceases to separate any more of that white substance, the oil is decanted off into another phial for use.

Passing over the processes of manufacture of many kinds of oil of less importance, we proceed to take linseed-oil, or the oil extracted from the seeds of the flax-plant, as an illustration of the manufacture of oil from seeds. "Linseed, rape-seed, poppy-seeds, and other oleiferous seeds were," Dr. Ure observes, "formerly treated for the extraction of their oil, by pounding in hard wooden mortars with pestles shod with iron, set in motion by cams driven by a shaft turned with horse or water-power; then the triturated seed was put into woollen bags, which were wrapped up in hair-cloths, and squeezed between upright wedges in press-boxes, by the impulsion of vertical rams driven also by a cam mechanism." In the best mills on the old construction, he adds, the cakes of crushed seeds obtained by this first wedge-pressure were ground anew upon the bed of an edge-mill, and subjected to a second pressure, with the aid of heat. "These mortars and presses," he states, "constitute what are called Dutch mills: they are still in very general use both in this country and on the Continent, and are by many persons supposed to be preferable to the hydraulic presses."

Owing to the extreme hardness and smoothness of the seeds of flax and hemp, and to the circumstance that the fragments of their shells, however broken, form minute concavities which will retain the oil unless a greater pressure be applied than could be given by an ordinary screw-press, the presses employed for extracting oil from such seeds differ materially from those used in crushing olives and other comparatively soft oleaginous substances. Hence it is that the wedge-press and Bramah's hydraulic press have been introduced for the purpose. Of these two powerful machines some manufacturers prefer the former, believing that the same degree of pressure is more efficient when imparted by means of sudden impulses or blows upon the end of a wedge, than when it is applied gradually and steadily as in the hydraulic press. In the wedge-press, of which there are many varieties, the crushed seeds are put into bags of hair-cloth or some similar material, and these bags are then placed between plates of iron united together like the covers of a book, or between boards or blocks of wood, within a very strong and massive framework. The small end of a wedge is then introduced in such a way between the plates or boards that, when it is driven down by the blows of a ram or pestle, it may compress the bags with enormous force. The driving of the wedges is continued until they are so tight that the pestle rebounds from them three times, when they are judged to be sufficiently driven. The use of the hydraulic press instead of this apparatus needs no minute explanation. Some of these act horizontally, the bags being, as in the wedge-press, placed vertically, and separated from one another by cast-iron plates; but in others the bags are piled upon one another in cast-iron cases, and placed in a vertical press. The seed is put into bags of flannel or of horsehair. Among other advantages it is stated that the hydraulic or hydrostatic press requires less space than a stamping-mill which could do the same work, and that the hairs and bags are found to last longer with it than with the old machine.

A mode much adopted in this country, of obtaining linseed oil, we shall now describe. As the hardness and smoothness of the seed gives it a tendency to slide away unbroken under the rolling action of the millstones by which they are ground, it is desirable, before taking it to the grinding-mill, to bruise or crush the seed by causing it to fall from a hopper between two iron crushing-rollers, placed side by side, and capable of being pressed against each other with any determinate degree of force; but the use of such rollers is by no means universal, the seeds being, in many cases, submitted to the grinding-mill without any such preparation. This mill, which is sometimes called an *edge-mill*, consists of a pair of stones, technically called *running-stones*, or *runners*, usually made of granite, resembling grindstones in shape, and from five to seven feet or upwards in diameter, so mounted as to roll round in a circular path of small diameter upon a solid horizontal bed of stone or iron laid beneath them. These stones, which roll round the bed from thirty to thirty-six times in a minute, are sometimes hooped with iron, though many prefer the rough surface of the granite, which may be re-dressed with a hammer as often as is needful. They grind the seed partly by their weight, which often amounts to three tons each, and partly by the peculiar rubbing motion which arises from the circumstance that the outer edge of the stone has to perform a larger circuit than the inner, although the two must of course revolve round the axle at one and the same speed. The action is therefore similar to that of a cone when forced to roll onward in a straight path. The two running-stones are mounted on the same horizontal axis, but at rather different distances from the central vertical shaft or axis round which they roll, so that they do not follow one another in precisely the same path on the bed of this mill. The bed is surrounded by a rim which prevents the seeds from being scattered; and the revolving framework in which the running-stones are mounted carries also two rakes or sweeps, which collect and lay the seeds in a ridge along the circular path of the runners. By this means the seeds are reduced, by the partial expression of the oil, to a pasty mass, from which a limited quantity of very fine *cold-drawn* oil may be obtained by the simple action of the press.

We have hitherto spoken only of the extraction of the finest oil, without heat. The application of heat before pressing is however necessary for obtaining the principal supply of oil. The precise order of the several operations, as well as the nature of the machinery employed, differs in different manufactories. In some establishments the oil-cakes, or solid contents of the bags, which remain after the first cold pressing, are taken out of the bags, broken to pieces, and put into mortars to be pounded by pestles worked by machinery. There the paste is again broken down, and the parenchyma of the seed reduced to a fine meal; thus free egress is allowed to the oil from every vesicle in which it is contained; but it is now rendered much more clammy by the forcible mixture of the mucilage, and even of the fine parts of the meal. When sufficiently heated it is removed to a *chauffer*, or circular copper-pan; in which, while it is kept continually stirred by machinery, it is heated to about the temperature of melting bees-wax, either by a charcoal fire, or according to a more recent practice, by steam. It is then, while hot, put into the bags and subjected to a second pressing; and in some cases the like operations are repeated a third time, by which a further quantity of oil, but of inferior quality, is produced. Sometimes the produce of oil is increased by mixing a little water with the paste; but this practice is considered to impair the quality of the oil. The oil-cakes which remain after the last process are used as food for cattle, and for various other agricultural purposes; but of course the cakes vary greatly in richness according to the degree in which they have been divested of oil. There are small mills in Holland which have no other employment than extracting oil from the cakes which they purchase from the French and Brabanters, after passing the process of their mills: a clear indication of the superiority of the Dutch practice over that of their neighbours. In some of the Dutch mills, the produce is increased by the application of moderate heat during the grinding process, by enclosing a little

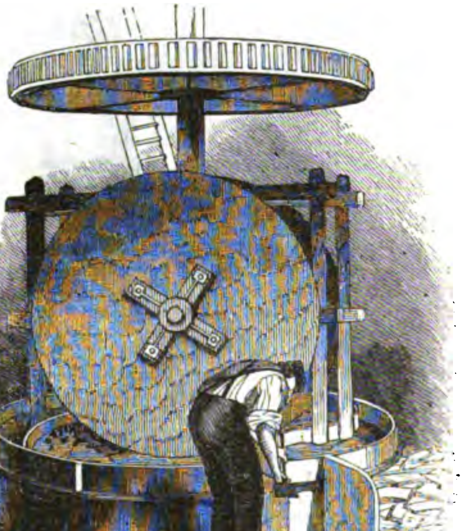


Fig. 1.—Linseed Crushing.

furnace in the bed upon which the running-stones roll; but the utmost care is necessary to prevent the heat from becoming too considerable, as it causes the oil to dissolve too much of the fermentable substance of the seed, and exposes it to the risk of soon growing very rancid. When the seed is very dry the process of grinding may be facilitated by the addition of a little water. The oil produced by the above process needs little further attention. If left in a cistern, as it is by the Dutch manufacturers, the parenchymatous part, which inevitably passes away with the oil in some degree in the operation of pressing, will gradually subside, and the oil may be drawn off at various levels, of different degrees of purity; the bottom being at length removed to a deep and narrow cistern, where it should be left a considerable time for the dregs to subside.

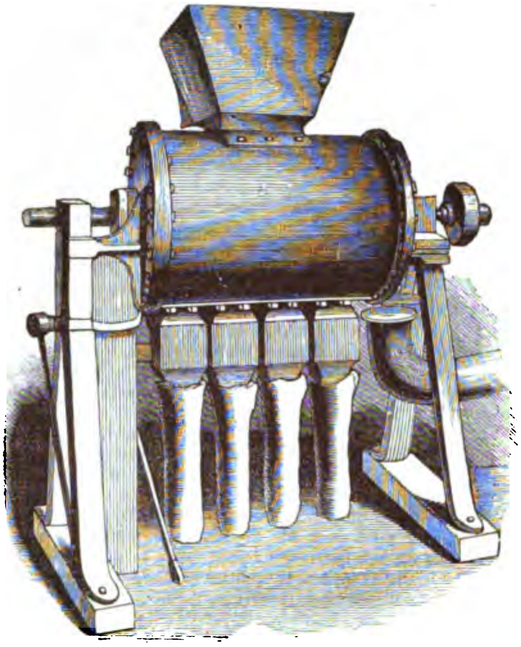


Fig. 2.—Ground Linseed falling into bags.

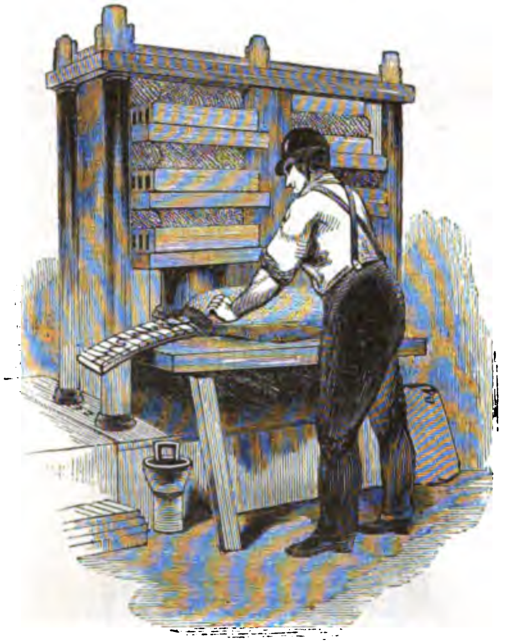


Fig. 3.—Bags of Linseed in the Hydraulic Press.

The annexed cuts represent three stages in the process of obtaining linseed oil by the hydraulic press; namely, the crushing of the seeds between edge-rollers; the falling of the seeds into bags after grinding; and the piling of the bags in the hydraulic press.

Mr. Samuelson, in a paper read before the Society of Mechanical Engineers, in 1858, entered fully into the respective merits of the different modes of expressing linseed oil. The latest and best arrangement he stated to be that of Blundell's double hydrostatic press, with two presses and two pumps, all connected by hydraulic tubing. The larger pump is weighted to 740 lbs. per square inch pressure; the smaller to 5540 lb. Each press works four bags of seed at once. A pressure of 40 tons is brought to bear on the seed in the first instance; and this is succeeded by one of 300 tons. Each press produces 36 cwt. of oil cake per day of 11 hours, and 14 cwt. of oil. It is a curious feature in this new form of hydraulic press, that it is worked with limpid oil instead of with water. Mr. Samuelson stated that there are now more than one million quarters of linseed pressed for oil annually in England; that two-thirds of the whole trade is centred at Hull; and that the produce comes out as about 144,000 tons of oil-cake and 56,000 tons of linseed oil.

Linseed oil is used principally as a vehicle for mixing oil-colours for painting, but it is also valuable in several branches of manufacturing industry, and, in a refined or purified state in some medicinal preparations. Being a fat or unctuous oil, it is slow in drying, and as this is a great inconvenience for some purposes in painting, it is sometimes converted into *drying oil* by boiling it with sugar of lead, white vitriol, red lead, or other substances which possess similar properties. The common kinds of drying oil are generally known by the name of *boiled oil*.

The trade in *lard oil* in America is so remarkable, in its origin and its nature, as to deserve a few lines of notice. When the British commissioners were at the New York Exhibition in 1853, they obtained information, among other things, concerning what in America is called *hog industry*. About the year 1830, farmers in the central states, especially Ohio, unprovided with cheap means of sending their produce to market (for there were no railways in those days), hit upon the plan of converting their corn into living meat, which could "walk itself off to market,"—in other words, fattening hogs. The trade grew year by year; until at length the city of Cincinnati soon became the centre of vast operations. The farmers in the country districts rear hogs, from 100 to 1000 on each farm. Drovers or jobbers come and purchase them, and drive them to Cincinnati, where they sell them to capitalists. These capitalists engage the services of killers, salters, curers, and packers, who keep large establishments in and near the city. The hogs, when still in the farmers' hands, are allowed to roam about in the woods, and feed themselves on acorns and beech-mast; but when the time for sale is approaching, they are called in, and fattened with an abundance of corn. Their average age at the time of sale is about 15 months, and average weight 200 lbs. When they arrive at the killing establishments, they are driven up an inclined plane to the upper floor or story, where they are penned for a short time. They next descend to the killing-room, where a poleaxe and a knife speedily end their existence. The dead bodies are at once thrown into a huge scalding tank, where the heat of hot water brings the outer skin to a state fit for subsequent operations. They are quickly passed to another room, where all refuse, from within and without the animal, is removed. All this is the work of the killers, who find a useful market for everything—skin, bristles, fat, intestines, blood, hoofs, &c.: nothing is wasted. In 1852 there were ten vast slaughtering establishments in Cincinnati, at which no less than 400,000 hogs, weighing 80,000,000 lbs., were slaughtered in twelve months. From the slaughterers, the carcases go to the curers and packers. Here the hogs are cut up into joints with surprising rapidity. Two men, the commissioners say, will cut up 850 hogs in a day of 13 hours, with two other men to carry and lift the carcases, and a fifth to trim the 1700 hams. The hams and shoulders are salted and cured; the middle pieces are salted, to make pickled pork, and packed in barrels for the navy and for foreign trade. The heads, the trimmings, various other parts, and sometimes (in a dull state of the provision market), nearly the whole carcase, are *rendered*, or digested in steam tanks to get out the fat in the form of lard. In one establishment alone, 3,000,000 lbs. of hog's lard were thus obtained in 1852. The lard is to some extent used as a substitute for butter, in cooking and culinary operations; but it is much more extensively applied to the production of *lard-oil* and *stearine*. When pressed in a hair-cloth bag, the lard yields from 40 to 70 per cent. of oil; the rest is a white solid stearine. The stearine is used for candles. The lard-oil, after being refined at a temperature of 200° Fahr., is used for soap-making, and for cheapening finer oils. In 1852, there were more than thirty lard-oil factories in Cincinnati alone. This city is, as we have said, the greatest centre of the trade; but it is not the only one. In eight of the middle states of the Union, there were, in the season 1852–3, more than 2,000,000 hogs cut up for meat, oil, stearine, &c.—the killing and salting being generally effected during the winter months.

The oil trade of this country is now a very considerable one. In 1859, the exports included (in round numbers) 20,000 tuns of train oil, blubber, and spermaceti; 20,000 tuns of olive oil; 11,000 tuns of various kinds of seed oil; 185,000 cwts. of cocoa-nut oil; and the enormous quantity of 686,000 cwts. of palm oil. Few circumstances, in connection with the recent history of our manufactures, are more important or interesting than the rapid increase in the palm-oil trade. The collecting and shipping of this product are the work of free persons in Africa; English gold finds its way thither in exchange; and it is possible (though the evidences of the fact are as yet very few) that the slave trade may be lessened by this gradual familiarising of the natives with the commercial dealings of Europe. The imports of whale oil are decaying, partly on account of the scarcity of whales in the North Atlantic, and partly owing to the increase in the use of vegetable oils. Of the seed oils, a large proportion is now Colza, or rape-seed oil, imported for use in lamps. In 1859 our farmers used 95,000 tons of oil cake, in addition to that obtained from oil-mills in this country. Of the 1,270,000 quarters of linseed imported, all but a small proportion was pressed for oil, the seed for sowing being comparatively small in quantity. In the same year, England exported nearly 8,000,000 gallons of seed oil; this was nearly all linseed oil, and was probably mostly for use in house-painting.

OILS, ESSENTIAL. [Essential Oils.]

OILS, FIXED. [Fixed Oils.]

OILS, VOLATILE. [Essential Oils.]

O'LEA EUROPÆA, *Medical Properties of*. A peculiar resiniform, balsamic exudation from the tree, the leaves, the fruit, and oil from the fruit, of this tree are all in use, but in Britain the oil only is officinal. The resin contains a peculiar matter termed *olivile*, a brown resin, and benzoic acid. The leaves have a peculiar crystalline febrifuge substance, useful against intermittents. ('Pharmacopœia.') The olive oil is itself used to adulterate cod liver oil; but this is in every way disadvantageous to the patient, as it is quite as apt to cause nausea, and is by no means productive of so much good as cod liver oil. (See 'Lectures on Pulmonary Consumption,' by Theophilus Thompson, p. 88.)

Olive-oil, on account of its high price, is frequently adulterated with poppy or rape oil. The former may be easily detected, if present in the proportion of only 1 per cent., as it retards the solidification of the oil, when a mixture, consisting of 9 parts of nitric and 3 parts of hyponitrous acid, is added to 100 parts of the suspected oil. The presence of metals may be detected by sulphuretted hydrogen. For various means of applying these and other tests, see Thomson's 'Organic Chemistry—Vegetable Substances,' p. 435; and notes in 'Edinburgh Pharmacopœia.'

Olive-oil is used in medicine as an emollient, and to form cerates and plasters. It is also used in the manufacture of soap. The finest kind is much employed with various articles of food, particularly in the countries where it is produced.

As this oil becomes viscid more slowly than any other vegetable oil, it is used, after being purified, by watch-makers.

OLEATES. [Oleic Acid.]

OLEENE. [Hexylene.]

OLEFIANT GAS. [Ethylene.]

OLEIC ACID. As oleate of glycerin, or olein, this acid forms the greater portion of all drying oils and the fluid part of nearly all fats.

Olein or *elain* ($C_{114}H_{104}O_{12}$). It was first observed by Chevreul that expressed oils and different kinds of fat usually contain two oils of different degrees of fusibility, or in other words, two different fatty substances; so that on cooling any expressed oil, one part of it became solid, while another portion retained its fluidity. In consequence of this observation he concluded that all expressed oils are similarly constituted; to the less fusible oil he gave the name of *stearin* (from *στέαρ*, suet), and the more fusible he termed *elain* (from *ἔλαιον*, oil), which was afterwards changed to *olein*.

Several methods have been proposed for separating these two substances. When olive oil, for example, is exposed to a low temperature, a portion of it becomes solid, and the remainder retains its fluid form; the former is *stearin*, or *margarin*, and the latter *olein*; these are separated by absorbing the liquid part by blotting-paper, and pressing the solid portion between folds of this paper till it ceases to render it greasy. The olein which the paper has absorbed is then to be separated from it by boiling it in water, on which the olein floats, and the paper sinks.

Olein has scarcely any taste or smell when procured from oils which possess these properties only in a slight degree. Its specific gravity is 0·98, it solidifies at 27° Fahr., and crystallises in needles. In water it is quite insoluble, but alcohol takes it up largely when boiling; by the alkalies potash and soda it is readily saponified, and during this operation oleic acid is formed by a new arrangement of the elements of the olein and their action on the elements of water; and these changes occur without the evolution of any gaseous matter.

On account of the very low temperature at which olein congeals, it is well adapted for lubricating the wheels of watches, and its value in this respect is enhanced by its not readily becoming rancid by the action of the air.

Although olein is frequently regarded simply as teroleate of glycerin, its constitution is more correctly expressed by regarding it as glycerin $\left.\begin{matrix}C_6H_5{}'''\\H_3\end{matrix}\right\}O_6$ in which three equivalents of hydrogen are replaced by three of the acid radical ($C_{36}H_{33}O_2$). Berthelot has indeed succeeded in forming this compound (*terolein*) artificially, as well as *diolein* and *monolein*. The processes he adopted have already been described under Glycerin; the following formulæ will however show the relations the compounds in question bear to each other:—

$$\underbrace{\left.\begin{matrix}C_6H_5{}'''\\H\\H\\H\end{matrix}\right\}O_6}_{\text{Glycerin.}}\qquad\underbrace{\left.\begin{matrix}C_6H_5{}'''\\C_{36}H_{33}O_2\\H\\H\end{matrix}\right\}O_6}_{\text{Monolcin.}}\qquad\underbrace{\left.\begin{matrix}C_6H_5{}'''\\C_{36}H_{33}O_2\\C_{36}H_{33}O_2\\H\end{matrix}\right\}O_6}_{\text{Diolein.}}\qquad\underbrace{\left.\begin{matrix}C_6H_5{}'''\\C_{36}H_{33}O_2\\C_{36}H_{33}O_2\\C_{36}H_{33}O_2\end{matrix}\right\}O_6}_{\text{Terolcin.}}$$

Elaidin is a solid modification of olein, and is produced when the latter is subjected to the influence of peroxide of nitrogen. [Elaidin.]

Linolein is the name given to the olein of linseed oil; it contains *linoleic acid* ($C_{46}H_{39}O_6$), differing apparently from oleic acid, but requiring farther investigation.

Oleic acid ($HO, C_{36}H_{33}O_3$). The preparation of this acid in the pure state is not an easy matter. Olein obtained in the manner above described still contains small quantities of margarin and stearin, and on saponification with an alkali yields margarate and stearate as well as oleate of the base. One of the best methods consists in saponifying with oxide of lead, digesting the resulting salts in ether for twenty-four hours, whereby oleate of lead only is dissolved; the oleic acid separated from the latter salt is super-saturated with ammonia, precipitated by chloride of barium, the oleate of baryta dried and boiled with alcohol, and the crystalline plates deposited on cooling finally decomposed by tartaric acid, when pure oleic acid separates.

Pure oleic acid is colourless, inodorous and tasteless. At about 40° Fahr. it solidifies into a hard white mass of acicular crystals, but at temperatures above 57° remains as a limpid oleaginous liquid, insoluble in water but soluble in alcohol or ether. It rapidly absorbs oxygen from the air, acquires a rancid smell and taste, turns litmus paper red, and has its point of solidification gradually lowered to below the zero of Fahrenheit's scale. By heat oleic acid is broken up into several gaseous and liquid bodies; among the latter is sebacic acid, a matter not obtained in the destructive distillation of the other oily acids.

It follows from what has been stated of the mode in which oleic acid is procured, that it enters largely into the composition of soaps, forming with potash soft soap, and with soda hard soap.

The *Oleates* in general are not crystallisable salts; and those which are not altogether insoluble are mucilaginous before drying; they are usually very fusible.

Oleate of Potash.—This salt has a bitter alkaline taste. When mixed with twice its weight of water, it swells and forms a transparent jelly; when this quantity of water is doubled, a syrupy liquor is obtained. A still larger quantity of water does not render it turbid, but after a considerable time a mucilaginous superoleate of potash separates. Alcohol dissolves its own weight of oleate of potash, when heated to 124° Fahr. and it solidifies on cooling; 100 parts of boiling ether dissolve 3·43 parts, and the solution remains fluid when cold.

Bi-oleate of Potash may also be formed; it is soluble in water and in alcohol both hot and cold, and the solution reddens litmus.

Oleate of Soda—Has a slight smell, and a slightly alkaline taste. Cold water dissolves 1-10th of its weight.

Oleate of Baryta ($C_{36}H_{33}BaO_4$) is insipid, and insoluble in water. Boiling alcohol dissolves only a small quantity. It is soluble in oleic acid.

Oleate of Magnesia—Has the form of semi-translucent white grains, which soften between the fingers.

Oleate of Copper.—This salt is green. It melts when exposed to the heat of the sun.

Oleate of Lead.—The neutral oleate is prepared in the moist way. It melts between 144° and 153° Fahr. Alcohol and ether dissolve it slowly when cold and rapidly when hot, without altering its neutrality.

Superoleate of Lead.—This salt is liquid at 75° Fahr., and below this temperature becomes an adhesive mass. Boiling alcohol dissolves a little of it, and deposits a neutral salt on cooling. Oil of turpentine and oil of petroleum dissolve both it and the neutral oleate.

Oleate of Methyl ($C_{36}H_{33}(C^2H_3)O_4$) has a specific gravity of 0·879 at 65° Fahr.

Oleate of Ethyl or *oleic ether* ($C_{36}H_{33}(C_4H_5)O_4$) is formed on passing a rapid current of hydrochloric acid gas into a solution of oleic acid in three times its bulk of alcohol. It is colourless, very soluble in alcohol, and has a specific gravity of 0·871 at 65° Fahr.

Sulpholeic Acid occurs among the products of the action of concentrated sulphuric acid upon olein; cold water decomposes a part of it with production of *metaoleic acid*, and the remainder on boiling is converted into *hydroleic acid*.

Chloroleic Acid ($C_{36}H_{32}Cl_2O_4$) is produced by the action of chlorine upon oleic acid. It is liquid at ordinary temperatures, has a brown tint and sp. gr. 1·082 at 46° Fahr. Its boiling point is 374° Fahr.

Bromoleic acid ($C_{36}H_{32}Br_2O_4$) much resembles chloroleic acid. Its sp. gr. is 1·272; boiling point 392° Fahr.

Elaidic Acid bears the same relation to oleic acid that elaidin does to olein; it may in fact simply be considered as a solid modification of oleic acid. It is produced, or rather induced, by the presence of a small quantity of peroxide of nitrogen. The oleic acid operated upon neither changes its composition nor its atomic weight; a small quantity is however acted upon, as traces of an oily body and of ammonia are generated, and it is not improbable that these communicate molecular motion to the particles of the oleic acid.

Elaidic acid melts at about 113° Fahr. It is soluble in ether or alcohol, and by spontaneous evaporation is deposited in beautiful pearly scales resembling benzoic acid. It is volatile, and may be distilled with but little alteration. Maintained at 150° Fahr. for some time it absorbs oxygen, acquires a disagreeable rancid odour, is converted into a liquid, and is no longer solidifiable by peroxide of nitrogen. Like oleic acid, it yields palmitic and acetic acid when fused with hydrate of potash.

Elaidic acid is of course produced when oleic acid or olive oil is acted upon by nitric acid or nitrate of mercury, the ultimate products of the action of excess of strong nitric acid are, however, acetic acid, propionic acid, butyric acid and the whole of the associated acids of the homologous series $C_nH_nO_4$, up to capric acid inclusive; as well as four terms of the dibasic acid series, $2HO,C_nH_{n-4}O_8$, namely, suberic, pimelic, adipic and lipic acids.

The *elaidates* have the same composition as the oleates. Those of the alkalies crystallise, and are soluble in water. *Elaidate of silver* is a white voluminous precipitate containing ($C_{36}H_{33}AgO_4$). *Elaidate of methyl* has the composition $C_{36}H_{33}(C_2H_3)O_4$. *Elaidate of ethyl* or *elaidic ether* ($C_{36}H_{33}(C_4H_5)O_4$) is a colourless, inodorous, tasteless oil of sp. gr. 0.868 at 65° Fahr. Boiling point about 590° Fahr.

OLEIN. [Oleic Acid.]

OLEOPHOSPHORIC ACID. An oily matter contained in the human brain, chiefly in combination with soda. According to Gobley it is also present in the yolk of egg. It is insoluble in water, but soluble in boiling alcohol and in ether. Alkalies break it up into phosphoric acid, oleic acid and glycerin. It has not yet been obtained in a state sufficiently pure for analysis; according to Frémy it contains from one and a half to two per cent. of phosphorus.

OLE'RON, LAWS OF. The laws, or constitutions, or judgments of Oleron, are a capitulary of ancient marine customs written in old French, and bearing the name of Oleron for several centuries, because tradition points to the island so called as the place of their original promulgation. An ancient copy of these laws is to be found in the 'Black Book' of the Admiralty, the original of which is supposed to be in the Bodleian Library; but they are not there called the Laws of Oleron, nor is there any reference in the laws themselves, or in the book which contains them, to their origin or history. They are not unfrequently appended to ancient editions of the 'Coutumier' of Normandy under the title of 'Les Jugemens de la Mer:' in Cleirac's edition of the 'Uz et Coutumes de la Mer' they are given, without any description of the book or place from whence they are taken, under the name of 'Roole des Jugemens d'Oleron.' They are generally referred to by French writers on maritime law as 'Jugemens d'Oleron.' The copies of these laws however published by Cleirac, and those appended to the 'Coutumier de Normandie,' differ materially from each other, and also from that in the 'Black Book' of the Admiralty, though many of the articles are almost verbally the same in all. They relate to the rights and duties of ship-owners and mariners, maritime contracts, port and custom laws, and losses at sea; but are chiefly remarkable at the present day from the circumstance that they were for several centuries adopted by all the nations of Europe as the foundation of their maritime laws.

It has been generally stated by English law writers that the laws of Oleron were compiled by Richard I. in the island of Oleron, on his return from the Holy Land. This statement, which is given by Coke, Selden, Hale, Prynne, Blackstone, Reeve, and several English writers on maritime law, furnishes a curious instance of the readiness with which historical errors are propagated when one writer makes his assertions respecting facts from the statements of another without thought or examination. There is scarcely any fact in history more entirely settled, and few more notorious, than that Richard I., in returning from the Holy Land, was shipwrecked in the Adriatic, near Venice, and immediately taken by Leopold, duke of Austria, and detained a prisoner in Germany ('Fœdera,' vol. i., p. 70); and there is good evidence that at the expiration of his captivity he returned home through Flanders, without touching upon his French dominions. (Hoveden.) It is equally clear, from the account of Hoveden and other chroniclers, that on his way to the East he travelled by land through France, and embarked at Marseille for Sicily. There is therefore not the slightest foundation for the statement which has been referred to; and indeed the only evidence that they were the work of Richard at all is found in what Sir Edward Coke calls a "notable" record in the Tower (4 Inst., 144), which record is also mentioned by Selden in his 'Mare Clausum' (lib. ii., cap. 24). The part of this record however in which these laws are noticed is dated in the reign of Edward III., and consequently 150 years after Richard's time; and the document appears hardly to deserve the name of a record, being merely a roll, consisting of detached membranes, relating to maritime affairs of different reigns, miscellaneously thrown together, and without any formal date or description, or anything to give them the authority of a judicial act. (Luders's 'Inquiry into the Origin of the Laws of Oleron.') This document contains the following passage, from which the story, ascribing this piece of legislation to Richard I. has sprung:—"Quæ quidem leges et statuta per Dominum Ricardum quondam Regem Angliæ, in reditu suo de Terrâ Sanctâ, correcta fuerunt, interpretata, declarata, et in insulâ Oleron publicata, et nominata in Gallicâ linguâ La Ley Oleroun." On the other hand, there are strong reasons for attributing to these ordinances a later date than the reign of Richard I., the principal of which are:—1. that they are written in the French language; whereas in the reign of Richard I. all laws of royal ordinance, both in the king's French dominions and in England, were written and promulgated in Latin; 2, that if they had been promulgated in England before the time of Bracton, Britton, and Fleta, they must have been mentioned by those authors; and 3, that the original historians of the reign of Richard I. (though sufficiently ready to record his merits) never mention this part of his legislation.

Mr. Luders conjectures that these laws did not proceed from any royal ordinance; but that the men of Oleron, who had corporate privileges granted to them by the name of "Burgenses de Olerone," in the reign of John ('Fœdera,' vol. i., pp. 111, 112), and had very considerable trade as early as the 12th century, may have collected adjudged cases upon the laws of the sea, for regulating their own maritime affairs;—that hence the laws of Oleron derived their name; and being received in England and France, became known and partially adopted in other nations of Europe. To the copies of the laws appended to the 'Coutumier de Normandie,' and also to those given by Cleirac, in the 'Uz et Coutumes,' an attestation by the seal of the Isle of Oleron is attached, with the date of 1266. This seal is inventoried as having been once in the treasury of the Court of Exchequer. See Palgrave's 'Kalendars and Inventories of the Exchequer,' vol. i., p. 106.

OLI'BANUM. This name, of frequent occurrence in comparatively modern works, does not seem to have been known to ancient commerce or Materia Medica. It appears to have been derived from the Greek λίβανος, or the Arabic *looban*, which is applied, as well as the name *Koondur*, to the substance known in Europe by the name Olibanum. Avicenna describes a resinous substance under the name *Koondur*, to which, in the Latin translations, Olibanum is given as a synonyme, as well as *Thus*, and with this the Arabian author includes a description of the bark, manna, and smoke of Thus, or frankincense; in the same way as we find, in Dioscorides, the description of Libanos, or Thus, followed by that of the other parts we have mentioned, indicating, as is evident indeed from the description, that Avicenna, under *Koondur*, refers to the λίβανος of Dioscorides. Both authors mention an Indian kind of the substance. Mr. Colebrooke ascertained ('Asiatic Res.,' ix. and xi.) that *Koondur* was applied in India to a fragrant resin still used there as incense, and which he ascertained to be the produce of the tree which has been already described under the article Boswellia *thurifera*, in Nat. Hist. Div. The name *Koondur* appears derived from the Sanscrit *Koondooroo*, which is applied to *looban* by the Hindus. ('Fl. Ind.,' ii., p. 384.) The tree is common in the mountains of Central India, as well as in those of the Coromandel coast, together with *B. glabra*, the other species of the genus, and which extends as far north as 30° in the Sewalik or sub-Himalayan range of hills.

Dr. Royle mentions that he has collected off the trunk of this species, in the latter locality, some very clear, pure, and fragrant resin, which burns rapidly away with a bright light, diffusing a pleasant odour. Both species yield this fragrant resin, which is employed as incense in India, and which might be much more extensively collected than at present. From the affinity in vegetation between parts of Arabia, Persia, and India, it is not improbable that the genus Boswellia may extend to Arabia, and there produce the kind known as *Arabian Olibanum*, the tree yielding which has not yet been traced out by botanists. It grows between Berberra and Cape Gardafin, and is exported in Arab vessels. A species of Boswellia would appear to grow in the island of Socotra. See Welstedan, 'Journal of Royal Geographical Society,' vol. v. The conjecture that African olibanum is the produce of *Plöslea-floribunda* (Endlicher) is very improbable, as no sapindaceous plant yields a resinous juice. But with respect to most of the Arabian exports, it is difficult to know whether they are the produce of that country, or have been first obtained by commerce and then re-exported, whence in early times Arabia obtained celebrity for producing so many of the fragrant and aromatic substances which we now know were obtained from Africa and India.

Dr. Royle further states that in Bengal the name *looban* is applied to Benzoin, though in Northern India applicable only to Koondur, the produce of *Boswellia thurifera*, and also that in Persian works, Benzoin is distinguished by the names "hussee-al-jawa" and "hussee looban." ('Illustr. Himal. Bot.,' pp. 177 and 261.)

Olibanum, or true frankincense, is now little used in medicine or surgery. It is burnt as incense, and enters largely into the composition of pastilles.

This substance must not be confounded with common frankincense, the produce of *Abies excelsa*, or common fir.

OLIDIC ACID. [Palmitic Acid.]

OLIVE OIL. [Oils, Manufacture of.]

OLIVILE. ($C_{28}H_{18}O_{10}$?) A colourless crystalline substance found in the resin of the olive. It is soluble in hot water and very soluble in alcohol. Submitted to dry distillation it yields *pyrolivilic acid* ($C_{40}H_{13}O_{10}$). Concentrated hydrochloric or sulphuric acid converts it into a red matter called *olivirutin*.

OLIVIN. [Saliginin.]

OLIVIRUTIN. [Olivile.]

OLYMPIAD. [Æra.]

OLYMPIAN GAMES, the chief of the four great national festivals of the Greeks, were celebrated at Olympia, a sacred spot on the banks of the Alpheus, near Elis, every fifth year. The exact interval at which the Olympia, as the festival was called, recurred was one of forty-nine and fifty lunar months alternately; so that it fell sometimes in the month of Apollonius (July), sometimes in the month of Parthenius (August). (Boeckh ad Pind. 'Olymp.,' iii. 18, p. 138; Müller's 'Dorians,' vol. i., p. 281, trans.) The period between two celebrations was called an Olympiad. The celebration lasted five days.

The origin of this festival is concealed amidst the obscurity of the mythic period of Grecian history. Olympia was a sacred spot and had an oracle of Zeus, long before the institution of the games. The Eleans had various traditions which attributed the original foundation of the festival to gods and heroes at a period long before the Trojan War; and among these to the Idæan Heracles, to Pelops, and to Heracles the son of Alcmena. The Eleans further stated, that after the Ætolians had possessed themselves of Elis, their whole territory was consecrated to Zeus; that the games were revived by their king Iphitus, in conjunction with Lycurgus, as a remedy for the disorders of Greece; and that Iphitus obtained the sanction of the Delphic oracle to the institution, and appointed a periodical sacred truce, to enable persons to attend the games from every part of Greece and to return to their homes in safety. This event was recorded on a disc, which was preserved by the Eleans, on which the names of Iphitus and Lycurgus were inscribed. (Plutarch, 'Lycurg.,' 1; Pausan., v. 20, 21.) Other accounts mention Cleosthenes of Pisa as an associate of Iphitus and Lycurgus in the revival of the festival. "All that can be safely inferred from this tradition, which has been embellished with a variety of legends, seems to be, that Sparta concurred with the two states most interested in the plan, and mainly contributed to procure the consent of the other Peloponnesians." (Thirlwall's 'History of Greece,' vol. i., ch. 10.) The date of the revival of the festival by Iphitus is, according to Eratosthenes, 884 B.C.; according to Callimachus, 828 B.C. Mr. Clinton prefers the latter date. ('Fasti Hellenici,' vol. ii., p. 408, note h.) The Olympiads began to be reckoned from the year 776 B.C., in which Coroebus was victor in the foot-race. We have lists of the victors from that year, which always include the victors in the foot-race, and in later times those in the other games. (Pausan., v. 8. 3.)

This, like all the other public festivals, might be attended by all who were of the Hellenic race, though at first probably the northern Greeks and perhaps the Achæans of Peloponnesus were not admitted. Spectators came to Olympia not only from Greece itself, but also from the Grecian colonies in Europe, Asia, and Africa. Among them were solemn deputations sent to represent their respective states. Women however were forbidden to appear at Olympia, or even to cross the Alpheus, during the festival, under pain of death. But at a later period we find the chariots of women mentioned as taking part in the chariot-race, though it is at least doubtful whether the women drove their own chariots. An exception was made to this law of exclusion in favour of the priestess of Demeter, who was permitted to be present at the games, and had a place assigned to her opposite the judges: according to Pausanias (vi. 20) a similar privilege was accorded to virgins, but no other writer refers to such an exemption, and the passage in Pausanias is by some recent authorities believed to be corrupt. The management of the festival was in the hands of the Eleans. Originally indeed Pisa, in which state Olympia lay, seems to have had an equal share in the administration; but in the fiftieth Olympiad the Eleans destroyed Pisa, and from that time they had the whole arrangement of the games. They proclaimed the sacred truce, first in their own territories, and then throughout the rest of Greece. This truce took effect from the time of its proclamation in Elis, and while it lasted the Elean territory was inviolable, any armed invasion of it being esteemed an act of sacrilege. On this privilege the Eleans founded a claim to have their territory always considered sacred, though in fact they themselves did not abstain from war. As the presiding nation, they gave laws for the regulation of the festival, imposed penalties on individuals and states, and had the power of excluding from the games those who resisted their decrees. They actually thus excluded the Lacedæmonians on one occasion and the Athenians on another.

The Eleans appointed the judges of the contests, who were called Hellanodicæ. (Paus., v. 9. 4, 5.) They were instructed in the duties of their office for a period of ten months before the festival by Elean officers, called Nomophylaces (Paus., vi. 24. 3): they were sworn to act impartially, and an appeal might be made from their decision to the Elean senate. (Paus., vi. 24. 3.) Their number varied at different periods: in the 106th Olympiad it was fixed at ten, which was the number ever afterwards. The judges had under them officers, called ἀλύται (*alytæ*), whose business was to keep order. These officers were called μαστιγόφοροι (*mastigophori*) in the other Grecian games.

The Olympian festival consisted of religious ceremonies, athletic contests, and races. The chief deity who presided over it was the Olympian Zeus, whose temple at Olympia, containing the ivory and gold statue of the god by Phidias, was one of the most magnificent works of art in Greece. (Paus., v.) The worship of Apollo was associated with that of Zeus (Müller's 'Dorians,' vol. i., p. 279–281, trans.); and the early traditions connect Heracles with the festival. (Ibid., p. 453.) This is another proof of the Dorian origin of the games, for Apollo and Heracles were two of the principal deities of the Doric race. There were altars at Olympia to other gods, which were said to have been erected by Heracles, and at which the victors sacrificed. The most magnificent sacrifices and presents were offered to Zeus Olympius by the competitors and by the different states of Greece.

The games consisted of horse and foot races, leaping, throwing, wrestling, and boxing, and combinations of these exercises. 1. The earliest of these games was the *foot-race* (δρόμος), which was the only one revived by Iphitus. The space run was the length of the stadium in which the games were held, namely, about 600 English feet. In the 14th Olympiad (724 B.C.) the δίαυλος was added, in which the stadium was traversed twice. The δόλιχος, which consisted of several lengths of the stadium (seven, twelve, or twenty-four, according to different authorities), was added in the 15th Olympiad (B.C. 720). A race in which the runners wore armour (ὁπλιτῶν δρόμος) was established in the 65th Olympiad, but soon after abolished. 2. *Wrestling* (πάλη) was introduced in the 18th Olympiad (B.C. 708). The wrestlers were matched in pairs by lot; when there was an odd number, the person who was left by the lot without an antagonist wrestled last of all with him who had conquered the others. He was called ἔφεδρος. The athlete who gave his antagonist three throws gained the victory. There was another kind of wrestling (ἀνακλινοπάλη), in which, if the combatant who fell could drag down his antagonist with him, the struggle was continued on the ground, and the one who succeeded in getting uppermost and holding the other down gained the victory. 3. In the same year was introduced the *pentathlon* (πένταθλον), or, as the Romans called it, *quinquertium*, which consisted of the five exercises enumerated in the following verse, which is ascribed to Simonides:—

Ἅλμα, ποδωκείην, δίσκον, ἄκοντα, πάλην,

that is, "leaping, running, throwing the discus [DISCUS], throwing the javelin, wrestling." Others give a different enumeration of the exercises of the pentathlon. In leaping, they carried weights in their hands or on their shoulders: the object was to leap the greatest distance, without regard to height. In throwing, neither the discus nor the javelin was aimed at a mark, but he who threw farthest was the victor. In order to gain a victory in the pentathlon, it was necessary to conquer in each of its five parts. 4. *Boxing* (πυγμὴ) was introduced in the 23rd Olympiad (B.C. 688). The boxers had their hands and arms covered with thongs of leather, called *cestus*, which served both to defend them and to annoy their antagonists. Virgil ('Æn.,' v. 405) describes the cestus as armed with lead and iron; but this is not known to have been the case among the Greeks. 5. The *pancratium* (παγκράτιον) consisted of boxing and wrestling combined. In this exercise and in the cestus the vanquished combatant acknowledged his defeat by some sign; and this is supposed to be the reason why Spartans were forbidden by the laws of Lycurgus to practise them, as it would have been esteemed a disgrace to his country that a Spartan should confess himself defeated. In these games the combatants fought naked. (Thuc., i. 6.)

The horse-races were of two kinds. 1. The *Chariot-race*, generally with four-horsed chariots (ἱππῶν τελείων δρόμος), was introduced in the 25th Olympiad (B.C. 680). The course (ἱπποδρόμος) had two goals in the middle, at the distance probably of two stadia from each other. The chariots started from one of these goals, turned round the other, and returned along the other side of the hippodrome. This circuit was made twelve times. The art of the charioteer consisted in turning as close as possible to these goals, but without running against them or the other chariots. The places at the starting-post were assigned to the chariots by lot. There was another sort of race between chariots with two horses (δύωρις or σύνωρις). A race between chariots drawn by mules (ἀπηνὴ) was introduced in the 70th Olympiad, and abolished in the 84th. 2. There were two sorts of *races on horseback*, namely, the κέλης, in which each competitor rode one horse throughout the course, and the καλπὴ, in which, as the horse approached the goal, the rider leaped from his back, and keeping hold of the bridle, finished the course on foot: in this last only mares were permitted to run.

In the 37th Olympiad (B.C. 632) racing on foot and wrestling between boys was introduced. There were also contests in poetry and music at the Olympian festival.

All persons were admitted to contend in the Olympic games who could prove that they were freemen, that they were of genuine Hellenic blood, and that their characters were free from infamy and immorality. So great was the importance attached to the second of these particulars, that the kings of Macedon were obliged to make out their Hellenic descent before they were allowed to contend. The equestrian contests were necessarily confined to the wealthy, who displayed in them great magnifience; but the athletic exercises were open to the poorest citizens. An example of this is mentioned by Pausanias (vi. 10. 1). In the equestrian games moreover there was no occasion for the owner of the chariot or horse to appear in person. Thus Alcibiades on one occasion sent seven chariots to the Olympic games, three of which obtained prizes. The combatants underwent a long and laborious training, the nature of which varied with the game in which they intended to engage. Ten months before the festival they were obliged to appear at Elis to enter their names as competitors, stating the prize for which they meant to contend. This interval of ten months was spent in preparatory exercises; and for a part of it, the last thirty days at least, they were thus engaged in the gymnasium at Elis.

When the festival arrived, their names were proclaimed in the stadium, and after proving that they were not disqualified from taking part in the games, they were led to the altar of Zeus the guardian of oaths (Ζεὺς ὅρκιος), where they swore that they had gone through all the preparatory exercises required by the laws, and that they would not be guilty of any fraud, nor of any attempt to interfere with the fair course of the games. Any one detected in bribing his adversary to yield him the victory was heavily fined. After they had taken the oath, their relations and countrymen accompanied them into the stadium, exhorting them to acquit themselves nobly.

The prizes in the Olympian games were at first of some intrinsic value, like those given in the games described by Homer. But after the 7th Olympiad, the only prize given was a garland of wild olive, cut from a tree in the sacred grove at Olympia, which was said to have been brought by Heracles from the land of the Hyperboreans. Palm leaves were at the same time placed in the hands of the victors, and their names, together with the game in which they had conquered, were proclaimed by a herald. A victory at Olympia, besides being the highest honour which a Greek could obtain, conferred so much honour on the state to which he belonged, that successful candidates were frequently solicited to allow themselves to be proclaimed citizens of states to which they did not belong. Fresh honours awaited the victor on his return home. He entered his native city in triumph, through a breach made in the wall for his reception; banquets were given to him by his friends, at which odes were sung in honour of his victory; and his statue was often erected, at his own expense or that of his fellow-citizens, in the Altis, as the ground at Olympia which was consecrated to the games was called. Three instances are on record in which altars were built and sacrifices offered to conquerors in the Olympic games.

During the celebration of these games, Olympia was a centre for the commerce of all Greece, for the free interchange of opinions, and for the publication of knowledge. The concourse of people from all Greece afforded a fit audience for literary productions, and gave motive for the composition of works worthy to be laid before them. Poetry and statuary received an impulse from the demand made upon them to aid in perpetuating the victor's fame. [PINDAR, in BIOG. DIV.] The influence of the games was thus extended through every part of Greece. Whether the effect of the exercises themselves on the national character was good or evil, is a doubtful question. The exercises of the body, on which these games conferred the greatest honour, were condemned by some philosophers as tending to unfit men for the active duties of a citizen (Arist., 'Pol.,' vii. 14, 18; Athen., x., 413); while they were regarded by others as a most necessary part of a manly education; and as the chief cause of the bodily vigour and mental energy which marked the character of the Hellenic race.

The Olympian games continued to be celebrated with great splendour at Olympia under the Roman emperors; but at length fell into disrepute, and were formally abolished by Theodosius in A.D. 394. The above description of the Olympian games will serve also for the most part for the other three great festivals of Greece. The chief points of difference between them will be seen by referring to the articles ISTHMIAN GAMES, NEMEAN GAMES, and PYTHIAN GAMES. Several of the Greek states in course of time established festivals in imitation of the Olympian games, which they likewise called Olympia; but their reputation was for the most part local.

(Pausanias, v. vi., &c.; West's Pindar, *Preliminary Dissertation*; Wachsmuth's *Hellenische Alterthumskunde*, Th. i.; Krause, *Olympia, oder Darstellung der grossen Olympischen Spiele*; Thirlwall's and Grote's *History of Greece*.)

OMBROMETER. [RAIN-GAUGE.]

OMEN, a sign or prognostication of future events, supposed to be an intimation from a superior power. According to Varro (' De Ling. Lat.,' lib. v. c. 7), the word is derived from the language of a person speaking: "Omen, quod ex ore primum elatum est, *osmen* dictum;" which was also the opinion of Cicero (' De Divin.,' i., c., 45), who says, "Neque solum Deorum voces Pythagoræi observitaverunt, sed etiam hominum, quæ vocant *omina*" (the Pythagoreans attended to the words not only of gods but also of men, which they called omens). The term afterwards comprehended all signs of future events.

In all probability there is no nation that has not at some time entertained a belief in omens. We find traces of it in the Scriptures. Among the Greeks and Romans it was general. The Persians, the Arabians, the Scandinavians, the Germans, the Icelanders, the ancient Britons, were all imbued with this superstition; as were also the early Christians.

Many curious instances of Roman superstition with reference to omens are enumerated in Pliny (xxxviii. 2). The unlucky omens which preceded the battle of Cannæ are enumerated by Silius Italicus, lib. viii., v. 626, &c.; see also Lucan i., v. 522, &c. Pausanias (iv. 13) enumerates the omens which announced the fate of the Messenians in their struggle with the Lacedæmonians. Suetonius (' Jul.,' § 59) says that Cæsar, in landing at Adrumetum in Africa with his army, happened to fall on his face, which was reckoned a bad omen; but, with great presence of mind, he laid hold of the ground with his right hand, and kissing it as if he had fallen on purpose, he exclaimed, "Teneo te, Africa" (I take possession of thee, O Africa). A similar story is told of William the Conqueror, on landing at Pevensey.

Omens have been frequently spoken of with contempt by men of talent. Homer makes Hector say—

> "Without a sign his sword the brave man draws,
> And asks no omen but his country's cause."

Wythers, in his 'Abuses stript and whipt,' and Dryden and Lee in his 'Œdipus,' act iv., sc. 1, satirise this superstition. Butler frequently alludes to omens in his 'Hudibras;' and by no writer have they been more successfully ridiculed than by Gay in his fable of the 'Farmer's Wife and the Raven.'

A superstitious regard to omens in our own country formerly made a considerable addition to the stock of human misery. Generally speaking, we now look back with indifference on the trivial and ridiculous accidents which alternately afforded matter of joy or sorrow to our ancestors. Nevertheless, in many country places, a superstitious regard to omens still exists.

OMNIBUS. [STAGE CARRIAGE.]

OMNIUM, a term used in the Stock Exchange, to express the value, taken as an average, of the different stocks in which a loan is usually funded. Thus, a loan having been contracted for on a certain day, an average is made of the stocks in which such loan is contracted, at the price which they bore on that day, and the fund thus formed as an average of the whole is called Omnium. (M'Culloch's *Dictionary of Commerce*.)

ONION. The species from which the varieties of the common onion have been derived is the *Allium Cepe*. Its uses are almost universally known, and its cultivation is practised in most countries. It was used and liked in Egypt; and the Israelites, under Moses, murmured that they could no more procure it. (Numb., xi. 5.) In Great Britain it has been naturalised from an early date, but is not supposed to be indigenous. The range of latitude within which it may be grown extends from the tropics almost to the coldest verge of the temperate zone. Its leaves and roots are of an annual nature, inasmuch as they die in the course of a single summer, after perfecting a bulb; the latter however is biennial, and capable of putting forth fresh roots and leaves in the following season, and of acquiring an increase in its size.

Onions will succeed in any good rich soil, provided it be neither too wet and adhesive, nor, on the other hand, too dry and light. They may even be grown successively on the same spot for a number of years, contrary to what happens with the majority of crops. Abundance of well-prepared manure should be thoroughly incorporated in digging the soil. The dung of pigeons and poultry is used with advantage; and some, particularly the French gardeners, prefer sheep-dung.

The time of sowing the general crop is from the middle of February to the middle of April, according to the state of the ground and of the weather; but early sowing is best. The seeds may be sown broadcast or in very shallow drills: the latter mode admits of the ground being more easily stirred on the surface and kept clean. In either case the seeds should be covered as lightly as possible.

When the leaves indicate, by the general yellowness of their points, that their office has been performed, the necks should be bent, and the bulbs pulled-up soon after, and spread so that their fibres and stems may dry and wither in the sun. They may then be stored up in any dry airy situation.

Very large onions may be obtained by sowing thickly in April on poor soil, so that the produce in the first summer may be of small size. The crop is then taken up as above directed, and the smallest and firmest are selected for planting in rich and well-prepared soil in the following spring.

For a supply of young onions in spring, the sowing should be made in August. Onions are sometimes attacked by a grub at the root. Trenching the soil to a good depth, soot, charcoal-dust, and lime-water, have severally been successfully applied as remedies.

The following are the principal varieties:

Early Silver-skinned—valuable only on account of its earliness.

Silver-skinned—moderately large, flat, shining, white, mild.

Portugal—large, oblate, imported largely from the country of which it bears the name, but only adapted for a supply during the early part of winter; quality rather mild.

Tripoli—the largest of all the varieties: oval, or somewhat flattened, light red, mild, but does not keep long.

Spanish, or *Reading*—large, flat, white, mild; resembles the Portugal onion, but is better adapted for cultivation in this climate.

Strasburg—large, flat or globular, light red, tinged with green, strong-flavoured, and keeps well.

Deptford and *Globe*—are sub-varieties of the preceding, of milder quality, and yield generally good crops.

James's Keeping—large, pyriform, brownish-red; keeps remarkably well; flavour strong.

Blood-red— middle-sized, flat, deep red; keeps well, but of the strongest flavour, on which account it is medicinally preferred to the other varieties.

Yellow or *Straw-coloured* (*Ognon paille ou jaune* of the French)—small, globular, firm, valuable for pickling.

Two-bladed—small, roundish, green, with little foliage.

There are at least twenty varieties of the onion, of which the silver-skinned, two-bladed, and yellow are chiefly grown for pickling. The Portugal and Spanish can only be produced in England by means of transplanting, and growing for two summers. In Portugal it is sown in November and transplanted in April or May. The *Potato* or *Underground Onion* forms numerous bulbs below the surface, which attain maturity early in the summer. The *Tree* or *Bulb-bearing Onion* bears instead of flowers, small bulbs, which, being planted in spring, produce ground onions of good size, and very high flavoured.

ONOMATOPE'IA (*ὀνοματοποιΐα, ὀνοματοποίησις*), which literally means "the making of words," is the name given to those words which are formed, or supposed to be formed, by an imitation of natural sounds. Thus the words "to neigh," "to murmur," "to bleat," "to creak," and many others, are supposed to be merely imitations of natural sounds; but the number of such words has been greatly exaggerated by some grammarians. Aristophanes imitates the croaking of the frogs by **Βρεκεκεκὲξ κοὰξ κοάξ** ('Frogs,' l. 209), and Ennius the sound of the trumpet by the word *taratantara*. (Servius on 'Æn.,' ix. 503.)

ONONETIN. [ONONIN.]

ONONIN ($C_{62}H_{34}O_{27}$). A colourless crystalline, inodorous and tasteless body, extracted from the root of the *Ononis spinosa*. It is insoluble in water and ether, soluble in alcohol, and neutral in its reactions. Treated with boiling caustic potash it is transformed into *onospin* and formic acid:—

$$\underbrace{C_{62}H_{34}O_{27}}_{\text{Ononin.}} + 2HO = \underbrace{C_{60}H_{34}O_{25}}_{\text{Onospin.}} + \underbrace{C_2H_2O_4}_{\text{Formic acid.}}$$

By the action of dilute acids ononin yields *ononetin* ($C_{48}H_{22}O_{13}$?), a colourless crystalline and neutral body insoluble in water. It dissolves in ammonia, and the solution when exposed to the air becomes of a beautiful bright green colour.

ONOSPIN. [ONONIN.]

OPACITY is a condition of bodies by which they are incapable of transmitting light through them. It seems to depend upon the nature or disposition of the particles of bodies, but its precise cause is, at present, far from being understood. According to Newton, opacity may arise from the unequal densities of the particles of certain substances, in consequence of which the rays of light on entering those substances suffer such refractions and reflections as compel them there to remain, and cause them to be finally absorbed; while, in bodies of a homogeneous nature, as glass, diamond, &c., the light experiences so much less of these irregular actions that, except when the thickness of the medium is very great, it is enabled to pass quite through them.

The entire absorption of all the light which enters a substance, merely by the multiplied refractions or reflections which it undergoes within the mass, is difficult to conceive; and the advocates of the undulatory theory ascribe opacity to the unfitness of the pores, or intervals between the molecules of a body, for permitting the vibrations of the particles of ether without disturbing the molecules, which thus appropriate to themselves the *vis viva* which would otherwise have belonged to the transmitted ethereal vibrations. The same persons consider transparency to consist in such a disposition of the molecules of a body that the incident waves of ether can be propagated with a certain degree of freedom through the mass: some impediment to the propagation of the waves may exist in the most transparent substances; and hence when such substances have more than a certain thickness, the waves cease to be transmitted through them. [TRANSPARENCY; ABSORPTION OF LIGHT.]

OP'ERA (Ital., *work*), a regular drama set to music, always accompanied by scenic representation, frequently by machinery, and sometimes by dancing. It appears (according to Doni) to have originated at Florence towards the end of the 16th century. The true opera, as found on all the Italian stages, whether in Italy or elsewhere, and as performed in the French language at the Académie Imperiale, admits no speaking; all is recitation or air, &c.; while what is called opera in the national theatres of Germany and England, as well as the French *opéra comique*, is of a mixed kind—partly spoken, partly sung. In Italy the opera is divided into four kinds,—namely, the *sacred*, the *serious*, the *semi-serious*, and the *buffa* or *comic*. In France the division is into the *grand'opéra* and *opéra comique*. In Germany the divisions are more numerous, embracing the *grand opera*, the *serious*, the *tragic*, the *heroic*, the *romantic*, the *allegorical*, the *military melodrama*, the *comic*, and others.

The constituents of an opera, says Rousseau, are the poem, the music, and the decorations. The poetry addresses itself to the mind, the music to the ear, the painting to the eye; and it is the duty of the three to unite their powers, in order to move and make an impression on the heart. The truth is, that the poetry of an opera has long ceased to be considered otherwise than as a vehicle for music, and, but for the scenery and decorations, the saying of the Abbé Arnaud, that *the Italian opera is a concert, of which the drama is the pretext*, would be applicable to nine in ten of all productions of the kind that have appeared during the last seventy or eighty years.

The moment that the opera appeared out of its native country, and especially when it reached the British shores, it was attacked by a host of critics and wits. Addison and Swift were among the first to level the shafts of ridicule at it, and were followed by Pope, Young, and many others. Addison lived to retract his opinion; for some of the absurdities which the opera in its infant state presented were soon corrected, though certainly enough remained, and must for ever remain, to sanction the objections of those who tried, or may still judge, the melodrama by the cold stubborn laws of unpoetical probability.

This species of entertainment, though susceptible of much improvement, has not stood quite still while everything else, or nearly everything, has been advancing. That prominent feature, however, in the musical drama, which from the very first proved so obnoxious to ridicule, continues unaltered—the recitative, which provoked the satire of our forefathers, and is yet rather tolerated than approved by the many—if a fault, is, we believe, a fault not imputable to the moderns, but to those whom it has hitherto been thought right to consider as the models of dramatic propriety and poetical taste. This leads to an inquiry concerning the origin of the melodrama—that is, the musical drama, or opera.

That the opera, properly so called, whether Italian or French, is the offspring of the Greek drama,—an opinion that for years past has been gaining ground,—is supported by the most learned and able writers on the subject, and seems likely ere long to be universally adopted. The first that we have met with who has touched on this point is the "philosopher of Malmesbury," Hobbes, who, in a letter to Sir William D'Avenant, says, "There is, besides the grace of style, another cause why the ancient poets chose to write in measured language, which is this: their poems were made at first with intention to have them sung, as well epic as *dramatic* (which custom hath long time been laid aside, but *began to be revived* in part *of late years in Italy*), and could not be made commensurable to the voice or instruments in prose—the ways and motions whereof are so uncertain and undistinguished (like the way and motion of a ship in the sea), as not only to discompose the best composers, but also to disappoint sometimes the most attentive reader, and put him to hunt counter for the sense. It was therefore necessary for poets in those times to compose in verse." This letter is dated Paris, 1650; consequently, written anterior to the establishment of the Académie Royale, or French opera.

Dryden, in the beginning of the preface to his 'Albion and Albanius,' rather hastily calls the opera "a modern invention, though built upon the foundation of the ethnic worship," and conjectures that it was borrowed from the Spanish Moors; but in a postscript to the same he corrects himself in the following rather awkwardly-expressed manner: "Possibly the Italians went not so far as Spain for the invention of their operas; they might have it in their own country, and that by gathering up the shipwrecks of the Athenian and Roman theatres, which we know were adorned with scenes, music, dances, and machines, especially the Grecian." The learned Jesuit, Père Menestrier, in his work 'Des Représentations en Musique,' maintains that the ancient tragedies were chanted. Metastasio, in his 'Estratto della Poetica d'Aristotile,' expresses a most decided opinion that the Greek and Roman dramas, both tragedies and comedies, were sung, and cites in proof of this numerous classical authorities. Pye, in his 'Commentary on the Poetic of Aristotle,' while disputing some of the inferences of Metastasio, is obliged, though unwillingly, to acknowledge that the opera "most probably" is "a lineal and legitimate offspring of the Greek tragedy," and that the vastness of the Roman theatre "turned the necessary means of modulating the voice into a real musical accompaniment;" that is to say, the magnitude of the place rendered chanting or recitative unavoidable.

After collating what has been stated by various authors as to the date of its origin, we are persuaded that no regular opera was produced and publicly performed till Ottavia Rinuccini wrote and Jacopo Peri composed the drama of 'Euridice' for the nuptials of Henri IV. of France and Mary of Medicis. This was represented in a very splendid manner at Florence, in 1600, and there published in the same year. Dr. Berni tells us ('Hist.' iv. 25) that he was never able to find more than one copy of Peri's 'Euridice,' which was in the library of the Marchese Rinuccini, a descendant of the poet. Having the good fortune to possess this very rare work, which is now before us, we can corroborate what the musical historian has said of it, that it is printed in score and barred, two very uncommon circumstances at the time of its publication; that the recitative seems to have been not only the model of subsequent composers of early Italian operas, but of the French operas of Lulli; that figures are often placed over the base to indicate the harmony; that the time changes as frequently as in the old French serious operas; and though the word *aria* occurs, it is difficult to distinguish air from recitative by any superiority of melody, except in the choruses. There is no overture to this, but a musical prologue of seven stanzas instead, sung in the character of Tragedy. Peri, in an address to his *readers* (*à lettori*), gives an account of his orchestra, which was placed behind the scenes, and consisted of a harpsichord, a large guitar, a *lira grande* (that is, a *viol da Gamba*, according to Burney), and an arch-lute.

The Bologuese dispute with the Florentines the honour of having first produced a musical drama, but it appears that the 'Euridice' was performed in their city the year after it had been produced at Florence. The opera was introduced at Venice in 1637, at Naples in 1646, and at Rome in 1671.

The Italian Opera made its way to London by slow and cautious steps. The sudden introduction on the public stage of a foreign language, and that language delivered in recitative, would have put the tolerating spirit of our countrymen to a trial far too severe to be prudent; the event, therefore, which was anxiously wished for by the higher orders, to whom novelty is everything, and by those who had acquired a new taste in their travels, was gradually brought about. In July, 1703, Italian *intermezzi*, or "interludes and musical entertainments of singing and dancing," were performed at York Buildings. Two years after, 'Arsinöe,' translated from the Italian, the dialogue and narrative parts in recitative, and the singers all English, was produced at Drury Lane; the pit and boxes were allotted to subscribers. "Before and after the opera, dancing and singing, by Signora Margarita de l'Epine." In 1706, 'Camilla,' also a translation, was performed by the same persons in a similar manner. The next year witnessed a further and still bolder advance towards the final introduction of the exotic melodrama; 'Thomyris, Queen of Scythia,' was brought out at the same theatre, in which Urbani, a castrato, and two foreign women sang their parts in Italian, the other performers singing theirs in English! At length, in 1710, 'Almahide,' written wholly in Italian, and performed exclusively by foreign singers, was presented to the public at the Queen's Theatre in the Haymarket. Thus the Italian opera gained a settlement in this country; and in spite of some opposition and much ridicule by which it was at first attacked, soon became firmly fixed, and now seems to be as necessary, as a source of amusement to the metropolis of this kingdom, as any other favourite and long-established entertainment.

The Italian opera was brought into France in 1646, by the Cardinal Mazarin, and continued for some years to be performed at the Louvre; but the establishment of the Académie Royale des Musique, in 1670, superseded it, and except in 1772, when a troop of Italians represented Pergolesi's 'Serva Padrona' as an *intermezzo*, between the acts of Lulli's 'Acis et Galatée,' it never again was heard at Paris till introduced there early in the present century.

The grand French opera is the legitimate melodrama, being wholly musical, and was founded by Louis XIV. In 1669 that monarch granted letters-patent to the Sieur Perrin for the establishment of an 'Académie des Opéra en Langue Francaise,' who, taking as his partner the Sieur Cambert as composer, commenced his undertaking at the Théâtre de l'Hôtel de Guenégaud, in 1671, where he produced 'Pomone,' the poetry by himself, and set to music by his colleague. This is a pastoral drama, opening with a musical prologue of about thirty lines, in which the author has contrived to stuff a greater quantity of nauseous flattery of the *Grand Monarque* than perhaps was ever compressed into so small a compass. In 1672 the privilege was transferred to Lulli, who, with the assistance of Quinault, a lyric poet of very superior genius, conducted the Académie in a most able and successful manner till his death. [LULLI, in BIOG. DIV.] The *opéra comique* had its birth in France in 1750, in imitation of the Italian *opera buffa*. This, however, is of the mixed kind, the dialogue being spoken.

The genuine Italian opera has long flourished in Germany. On the birth of an archduchess in 1724, an opera was exhibited at Vienna with uncommon magnificence. The opera, entitled 'Eurysteus,' was written by Apostolo Zeno, and composed by Caldara. That imperial poet-laureate was succeeded in office by Metastasio, who wrote many of his admirable lyric dramas for the Italian theatre at Vienna, which were set by the great masters of the day. His 'Clemenza di Tito,' as composed by Mozart, will for ever be considered, by all true judges of dramatic poetry and music, as the most beautiful and finished example of the melodrama that human genius ever produced. For the different German courts some of the finest operas have been composed, but we can here only refer to the names of their authors, GLÜCK, GRAUN, HANDEL, HASSE, MOZART, ROSSINI, SPOHR, WEBER, WINTER, &c., in the BIOG. DIV.

What is called English opera, is with two or three exceptions, of the mixed kind. The first that we have any account of that can be relied on is Shadwell's 'Psyche,' composed by Matthew Lock, and brought out in 1673. Two years after, Dryden wrote his 'Albion and Albanius,' an opera, set by a Frenchman, Louis Grabut, whom, to please the antinational king, Charles II., Dryden, in a preface to the work, praises in high though most undeserved terms, at the expense of his countrymen. But when that great poet wrote his 'King Arthur,' he was fain to apply to Purcell for assistance, whose music has saved it from the oblivion to which it would otherwise be condemned. The poet, in an epistle-dedicatory to this, takes an opportunity of retracting his opinion of English composers. He says that music had then "arrived at a greater perfection in England than ever formerly; especially passing through the artful hands of Mr. Purcell, who has composed it with so great a genius, that he has nothing to fear but an ignorant ill-judging audience." Addison's 'Rosamond' was, it is to be supposed, a real opera, the dialogue in recitative. This was represented in 1707, but failed, as Hawkins tells us, owing to the poverty of the music by one Clayton. 'The Beggar's Opera' is so well known that it need only be named. The music is a good selection of the airs most popular at the time, arranged by the celebrated Dr. Pepusch. 'Artaxerxes,' by Dr. Arne, is the only opera, strictly so called, that keeps its place on the stage. This is nearly a translation of Metastasio's 'Artaserse,' by the composer himself, and though at the time severely criticised, is far superior to most of the musical dramas that have since been written. The music is rich in beautiful melody, and if other attempts at an English recitative opera had proved equal to this, the melodrama might now have been firmly rooted in British ground. Arne composed many other charming musical pieces; his 'Love in a Village' will never be superannuated; and in truth, if the dramatic music of some of our countrymen who charmed the public ear during the latter half of the last century could be heard without prejudice, and without that yearning after what is foreign and new which characterises "the fashionable world," and others who yield to its influence, it would be admitted that in original expressive melody we are inferior to no nation in Europe, startling as the proposition may be to those who have not impartially and duly considered the subject. [ARNE; ARNOLD; BISHOP; DIBDIN; JACKSON; LINLEY; SHIELD; STORACE; in BIOG. DIV.]

OPERATION. This article is to be considered as a continuation of ALGEBRA, and as a development of the views of the nature of algebra there laid down. It cannot be read entire, except by students who have some acquaintance with the Differential Calculus, &c.

The great considerations on which the mathematics are founded have always, until lately, been stated as those of number and space; so that arithmetic and geometry have been called the wings of this branch of exact science. This similitude, suggested by the twofold character of its objects of comparison, may be carried a step further; for as wings will not enable a bird to fly without nerves and sinews, so the mere consideration of space and number will never make a mathematician, without an organised method of using the ideas of both. We have already [MATHEMATICS] suggested that the science of operation must be a constituent part of mathematics; but it has always been so mixed up with the sciences bearing names derived from number and measure, that until lately it has had neither separate name nor existence; and even now, what has been done in it is only the mere beginning of a system.

The use of symbols of operation not standing for magnitudes but for directions how to proceed with magnitudes, began with Leibnitz and Newton, before whose time all algebraical characters denoted simple numbers. The progress of the Differential Calculus forced the attention of mathematicians upon modes of denoting, not results of processes, but ways of proceeding. The generalisations arising out of the organisation which notation gave to processes led to the use of indefinite and arbitrary symbols of operation. [FUNCTION.] Finally, it was observed that the symbols of operation employed in many general theorems would give simple and well-known relations if their meaning as symbols of operation were forgotten, and they were considered as symbols of quantity. For example, if $\Delta\phi(x)$ be $\phi(x+1)$ $-\phi x$, Δ being a symbol, not of a quantity multiplying ϕx, but of an operation to be performed upon ϕx; and if $\mathrm{D}\,\phi x$, $\mathrm{D}^2\phi x$, &c. denote the successive differential coefficients of ϕx, Taylor's theorem gives

$$\Delta\phi x = \mathrm{D}\,\phi x + \frac{1}{2}\,\mathrm{D}^2\phi x + \frac{1}{2\,.\,3}\,\mathrm{D}^3\phi x + \ldots.$$

If Δ and D had stood for quantities (which they do not), the preceding equation might have been divided by ϕx, and the result would have been

$$\Delta = \mathrm{D} + \frac{1}{2}\,\mathrm{D}^2 + \frac{1}{2\,.\,3}\,\mathrm{D}^3 + \ldots. = \epsilon^{\mathrm{D}} - 1 \ldots. (\mathrm{A})$$

If such a result had been obtained by those mathematicians who first ventured on the use of a negative quantity, they would doubtless have given to operations a sort of existence as quantities, and would have felt no repugnance to say that the direction to change ϕx into $\phi(x+1)$ $-\phi x$ was equal to ϵ raised to the power of a direction to differentiate ϕx, diminished by a unit. This might have beat their negative quantity (or arithmetical quantity less than nothing) in the complication of its absurdities, but not in absolute impossibility. Let two persons be required, the one to take four yards out of three, and the other to subtract a unit from—not the differential coefficient of ϕx, but—the direction to take the differential coefficient of ϕx, and it could hardly be said that the first had a more hopeless task than the second.

The modern mathematicians, with Lagrange at their head, had had too much experience of the nature of extensions to hazard any assumption upon the properties of symbols of operation, when separated from the quantity to be operated upon. The first step made was the observation that certain theorems involving symbols of operation might be easily remembered by the resemblance of the formulæ to well-known expressions; in fact, by the coincidence of those formulæ with the expressions, on the supposition that the symbols of operation are changed in meaning, and become symbols of quantity. And if it be said that these mathematicians were saved from introducing a difficulty analogous to that of negative quantities by the want of resemblances already existing in common modes of speaking and common views of arithmetic, it may be answered that such was not the case, but that it would have been easy, and was not without precedent, to consider arithmetic itself as a science of operations upon one single magnitude, the unit. If we always express the unit by I, we may, if we please, consider 2 not as $\mathrm{I}+\mathrm{I}$, but as the direction to perform upon I the operation in $\mathrm{I}+\mathrm{I}$; so that 2 being merely a direction what to do, $2\mathrm{I}$

may represent the result of so doing: similarly 3 may be the direction to proceed as in I+I+I, and 3I its result. And 3×2 would be a direction to perform 3 upon the result of 2, or to take 2I+2I+2I, or (I+I)+(I+I)+(I+I), or 6I. If then we say $3\times$(2I)=6I, we have an equation between magnitudes; but if we throw away I, as we just now did ϕx, we have $3\times 2=6$, an expression of equivalence of operations. Now it might very reasonably have been asked whether *these* operations must be the only ones which will admit of being treated by themselves and viewed independently of the subjects of operation; and a direct assumption of such modes of notation as that marked (A), even when Δ and D were considered independently, though it might not have been fully explicable, would have appeared to be nothing but a natural extension of views which had already been taken to a limited extent.

The process however which was actually followed was this: forms similar to (A) having been observed, in which, whatever might be thought of them as they stood, were found ready means of returning to well-known truths, it was natural to ask whether an application of algebra to the form (A), producing of course a transformation of both sides, would lead to a result from which, by the same method of returning, another known truth might be produced. For example, assume that D and Δ are to be treated as quantities: then $\Delta=\epsilon^{\mathrm{D}}-1$ gives $1+\Delta=\epsilon^{\mathrm{D}}$, log. $(1+\Delta)=\mathrm{D}$, or

$$\mathrm{D}=\Delta-\frac{1}{2}\Delta^2+\frac{1}{3}\Delta^3-\ldots.$$

Now restore ϕx to every term, and let D and Δ reassume their operative meanings, so that $\mathrm{D}\phi x$ is the differential coefficient, and $\Delta\phi x$, $\Delta^2\phi x$, &c., are the successive DIFFERENCES of ϕx, x being changed into $x+1$ at each step. We have then

$$\mathrm{D}\phi x=\Delta\phi x-\frac{1}{2}\Delta^2\phi x+\frac{1}{3}\Delta^3\phi x-\ldots$$

a theorem which must be true if the preceding method be legitimate. This theorem is found to be true by other and certain modes of demonstration: consequently the legitimacy of the preceding method has some presumption in its favour, arising from its leading to an otherwise known truth.

In this way many theorems were investigated, upon the following plan of proceeding:—1. Throw away symbols of quantity from a known theorem, and proceed in any manner which may appear eligible with the symbols of operation, treating them as if they were quantities. 2. When a result has been obtained, restore the symbols of quantity to their old places, and those of operation to their old meanings. 3. The result as thus viewed has all the presumption in its favour which arises from its being the legitimate consequence of a method which, whether accurate or not, has never been found to lead to anything but what could otherwise be satisfactorily shown to be true. And though Lagrange himself, Arbogast, the English translators of Lacroix, Brinkley, &c., may have used language in reference to this method which would seem to imply that they considered it as one of demonstration, yet it is obvious, from the care taken by them to have abundant external verification in every case, that their results were considered by themselves as resting on such a presumption as that above noted; though it is also evident that they considered the presumption as amounting to moral certainty, which indeed they were justified in doing.

A student who reads on this subject for the first time will be apt to let his ideas run farther than they should, and to imagine that this treatment of operations may be made universal. For instance, if $\phi x=x^2$ and $\psi x=x^3$, and if $\phi+\psi$ be taken as representing x^2+x^3, he might suppose that $\phi+\psi$ performed twice, or

$$(x^2+x^3)^2+(x^2+x^3)^3$$

represented by $(\phi+\psi)^2$, should be the same thing as

$$\phi^2+2\phi\psi+\psi^2,\text{ or }(x^2)^2+2(x^3)^2+(x^3)^3.$$

This however will be found not to be the case, and thus it appears that a line is to be drawn, distinguishing operations which may be used independently of quantities from those which may not. Until this line can be properly drawn, nothing like demonstration of the method, when true, can be given; or rather perhaps the converse, that is to say, a method of demonstration of such cases as give truths will draw the line which separates these from the rest. We proceed to give some account of this method of demonstration.

We do not know how far those who used the *separation of the symbols of operation and quantity* (as it was called) had before their minds a view that would have made their method intelligible in a rational point of view, which was all it wanted of mathematical exactness. But, looking only at their modes of expression, we cannot find anything of the kind. Lagrange ('Mém. Acad. Berlin,' 1772) gave only theorems without any mode of deducing them. Arbogast assumes the "séparation des échelles" without remark. Laplace, by the aid of his theory of generating functions, must be held to have strictly demonstrated some isolated classes of the theorems which this method gives. But nothing like a general account of the reason why this separation of the symbols of operation and quantity leads to truth in certain cases and not in others, ever appeared, to our knowledge, before the publication of a memoir by M. Servois in the 5th volume of the 'Annales de Mathématiques' (Lacroix, vol. iii., p. 726). The author exhibits those properties of the separable operations on which the legitimacy of the separation depends; and making a separate species of calculus of functions out of those properties, fully succeeds in demonstrating that differences, differentiations, and multiplications by any factors which are independent of the variables, may be used as if their symbols of operation were common algebraical quantities.

The last step towards the full conception of a *calculus of operations* was virtually made by Dr. Peacock, in his 'Algebra' (first edition, 1830); for though this work does not mention the subject, yet it is the first which lays down the principles on which the theory of separation is neither a resemblance of algebra, nor a calculus of functions founded on algebra, but *an algebra*, or if the reader pleases, algebra itself; so that its conclusions rest upon the same foundation as those of ordinary algebra.

We have [ALGEBRA] pointed out what is meant by symbolical algebra, as distinguished from explained or interpreted algebra. Granting a certain number of fundamental relations, which are to be true, the logical consequences of combining those relations must be true also: thus, if it be universally true that $a+b=b+a$, and that $xy=yx$, it follows, even before a, b, $+$, x, xy, &c., have any meaning assigned, that $(a+b)z=z(a+b)=z(b+a)$. If, as in the article cited, we select all the primary relations on which algebraical transformations depend, and then bear in mind that the truth of all their consequences depends on the truth of those relations only, not on the relations being true for one meaning or another meaning of the symbols, but on the truth only of the relations, come how it may—we shall then see that all formulæ of algebra may be used as expressions of truths, whatever may be the meaning of the symbols employed, provided only that, such meanings being given, the fundamental relations are true. We have already seen that this may be carried the length of extending the meanings of all the symbols of algebra, in such manner that a science is created with definitions wide enough to include among its rational objects not only the negative quantity, but also its square root. This was *extension* only; we shall now show a process which, though it be still extension, is of another character.

In our present inquiry, we need not trouble ourselves to make any particular consideration of the signs + and —. They retain their algebraical meaning, so that whatever A and B may stand for, $+(+\mathrm{A})=+\mathrm{A}$, $-(+\mathrm{A})=-\mathrm{A}$, &c.

If we now ask, what are the fundamental symbolical relations of algebra which remain, after those which depend on + and — are taken away, we shall find them to be as follows:—1. The *distributive* character, as it is called, of the operation ab, with respect to + and —, as shown in $a(b+c-e)=ab+ac-ae$. 2. The *commutative* or *convertible* character of the same operation with respect to others of the same kind and itself, as shown in $abc=acb=bca$, &c., and $ab=ba$. 3. The *depressible* character of operations of the species a^m, when performed upon other operations of the same kind, as shown in $a^m a^n=a^{m+n}$, $(a^m)^n=a^{mn}$. These laws of operation being granted, no matter what the nature of the interpretation under which it is found possible to grant them, all that is necessary to the mechanism of algebra will be found to have been granted. It will be remembered that we speak of $1\div a$ under the symbol a^{-1}.

In arithmetic, as already seen, we may, if we please, consider the symbols 2, 3, &c., as indicative of operations performed upon the unit. Let us extend this notion, and, instead of the unit, make ϕx, any function of a variable x, the subject of operation; this function being always understood, if not expressed. Thus any symbol E has an operative meaning in itself, but when written in an equation stands for the result obtained by performing that operation upon ϕx, which may also be signified by $\mathrm{E}(\phi x)$. Also let $\mathrm{E}+\mathrm{F}$ and $\mathrm{E}-\mathrm{F}$ stand for the algebraical sum and difference of the results of the operations E and F performed upon ϕx. Let us now appropriate E to stand for the simple operation of changing x into $x+h$, or $x+$ any quantity independent of x in value: and to distinguish the different increments, let E_h, E_k, &c., denote the operations of changing x into $x+h$, $x+k$, &c. It is then very easily shown that E possesses the distributive, convertible, and depressible characters essential to its being logically the object of algebraical transformation. Take two functions, ϕx and ψx, either assumed independently or resulting from preceding operations: it follows then that $\mathrm{E}_h(\phi x\pm\psi x)$ is $\phi(x+h)\pm\psi(x+h)$, which is $\mathrm{E}_h\phi x\pm\mathrm{E}_h\psi x$; or the distributive character is established. Again, consider $\mathrm{E}_h(\mathrm{E}_k\phi x)$ and $\mathrm{E}_k(\mathrm{E}_h\phi x)$: first, $\mathrm{E}_k\phi x$ means $\phi(x+k)$, on which perform E_h, or change x into $x+h$, giving $\phi(x+h+k)$; next, $\mathrm{E}_h\phi x$ is $\phi(x+h)$, on which E_k being performed, gives $\phi(x+k+h)$, the same as $\phi(x+h+k)$. Consequently $\mathrm{E}_k\mathrm{E}_h\phi x=\mathrm{E}_h\mathrm{E}_k\phi x$, or the convertible character of E is established. Thirdly, consider $\mathrm{E}_h^3\mathrm{E}_h^2$, meaning that the operation E_h having been twice performed, E_h is to be three times performed upon the result: we have evidently $\phi(x+5h)$, or $\mathrm{E}_h^5\phi x$; and if E_h^3 were to be performed four times running, we should have E_h^{12}. Hence the depressible character of the successive operations is established: and though it be a wide step or the beginner to make, the applicability of all the formulæ of algebra is now proved, subject, as in common algebra, to difficulties of interpretation occurring in results.

A simplification of the preceding notation may be made as follows: if E or E^1 be simply a direction to increase x by unity, and E^0 a direction to let it remain unaltered, it is clear that $\mathrm{EE}\,\phi x$ must mean $\phi\,(x+1+1)$, or $\mathrm{E}_2\,\phi x$; so that $\mathrm{E}^2\,\phi x$ and $\mathrm{E}_2\,\phi x$ are the same. Similar reasoning applies to E_h whenever h is a whole number; and shows that it is E^h and nothing else. Similar reasoning also applies to E^{-h} where h is a whole number: for E^{-h} must be so interpreted that E^h performed upon it may give E^{h-h} or E^0; that is, $\mathrm{E}^{-h}\,\phi x$ with x changed h times into $x+1$ must be $\mathrm{E}^0\,\phi x$, or ϕx; or $\mathrm{E}^{-h}\,\phi x$ must be $\phi\,(x-h)$. In like manner it may easily be shown that *one of the meanings* of $\mathrm{E}^{h}\,\phi x$, where h is fractional, is $\phi\,(x+h)$: but, as in common algebra, of which all the conclusions, as shown, here apply, when h is a fraction, E^h may be any one out of operations as many in number as there are units in the denominator of h. To take a very simple case, required $\mathrm{E}^{\frac{k}{2}}\,\phi\,(x)$, meaning an operation which, twice repeated, gives $\mathrm{E}^k\,\phi x$, or $\phi\,(x+k)$. This condition is evidently satisfied by $\phi\,(x+\frac{1}{2}k)$, but it is also satisfied by $-\,\phi\,(x+\frac{1}{2}k)$, for if part of the operation consist in change of sign, two repetitions of the operation reproduce the original sign.

It must not be forgotten that, in finding new objects of algebraical reasoning, we have not lost our rights over the old ones; thus any letter may stand for a multiplier or divisor of the universal subject of calculation, ϕx. *But these independent multipliers must not contain x:* for if they did contain x, the convertibility of the multipliers with E would not any longer be practicable. If, for instance, we consider $a\mathrm{E}\phi x$, which is $a\,\phi\,(x+1)$, we find it to be the same as $\mathrm{E}\,(a\phi x)$, for a, being independent of x, is not affected by E. But if we consider $x\mathrm{E}\phi x$, and $\mathrm{E}\,(x\phi x)$, we find the first to be $x\phi\,(x+1)$, and the second to be $(x+1)\,\phi\,(x+1)$. A wide branch of the calculus of operations exists, in which the convertible character of the operations is not made a postulate. Our limits will not allow us to enter upon it, except to a very small extent, as presently given: but there is one elementary work on the subject, Carmichael, 'Calculus of Operations,' 1855; and there is a good deal on the subject in Boole, 'On the Calculus of Finite Differences,' 1860.

To generalise the preceding, we may suppose $\mathrm{E}^0\phi x$ to mean ϕx as before, and $\mathrm{E}\phi x$ to stand for $\phi\,(x+a)$, where a may have any value we please independent of x. And it is in our power to abbreviate any collection of operations by using a single symbol to stand for it. Thus Laplace uses $\nabla\,\phi x$ to stand for such a set of operations as

$$\mathrm{A}_0\,\phi\,(x)+\mathrm{A}_1\,\phi\,(x+a)+\mathrm{A}_2\,\phi\,(x+2a)+\,\ldots.$$

which we should denote by

$$\nabla=\mathrm{A}_0+\mathrm{A}_1\,\mathrm{E}+\mathrm{A}_2\,\mathrm{E}^2+\,\ldots.$$

Again, if in common algebra fy were $\mathrm{A}_0+\mathrm{A}_1\,y.+\,\ldots.$, we might abbreviate the preceding into $f\mathrm{E}$ instead of ∇.

But it may be said that this, though intelligible as to a simple operation E, its repetitions E^2, E^3, &c., its inverse and repetitions of it E^{-1}, E^{-2}, &c., ceases to have meaning when we come to apply it to other functions of algebra. What, for instance, is log. $(1+\mathrm{E})$? How can the direction to add $\phi\,(x+a)$ to ϕx have a logarithm? This question arises from the student having carried with him into purely symbolical algebra (in which it is the first requisite to drop all meanings) significations of symbols derived from ordinary arithmetical algebra. Now it is to be remembered that as far as we have yet gone, all the transcendental symbols of algebra, a^{E}, log E, sin E, cos E, &c., have not been mentioned, far less defined; they are not therefore absurd, but only, for the present, unmeaning. The question is, how are we to give them meaning; at our pleasure, or by deduction? Evidently the latter, for we are bound to retain the power of using algebraical transformations as they now exist. Since then a^x in common algebra is equivalent to $1+\log a.\,x+\frac{1}{2}\,(\log\,a.)^2\,x^2+\ldots\ldots$ we must lay it down that $a^{\mathrm{E}}=1+\log a.\,\mathrm{E}+\ldots.$, or that a^{E} must be viewed, when it means an operation to be performed upon ϕx, as an abridgment of

$$\phi x+\log a.\,\mathrm{E}\phi x+\tfrac{1}{2}\,(\log a.)^2\,\mathrm{E}^2\phi x+\ldots.$$

This is unquestionably the most difficult step of the whole: we shall have occasion further to consider it in the article RELATION, but for the present the following may be sufficient. Since the total operation $\mathrm{A}_0+\mathrm{A}_1\,\mathrm{E}+\mathrm{A}_2\mathrm{E}^2+\ldots.$ can be easily understood, consisting merely of the successive performance of the operation E, the multiplication of the results by given quantities of common algebra, and the addition of the products; and since all the transcendentals of common algebra can be expanded, in series of the above form, in such manner that the series have all the algebraical properties of the transcendentals they stand for; let us consider the transcendental symbols of operation as abbreviations of the series, supposed to stand for series of operations.

We shall now proceed to some examples. First, let it be required to transform the series $\mathrm{A}_0\phi x+\mathrm{A}_1\,\phi(x+a)+\mathrm{A}_2\phi\,(x+2a)+\ldots.$ This may be represented by $\mathrm{A}_0+\mathrm{A}_1\,\mathrm{E}+\mathrm{A}_2\mathrm{E}^2+\,\ldots$ performed upon ϕx. Let the latter series in common algebra be $f\mathrm{E}$, then $f\mathrm{E}$, considered as a symbol of operation, stands for the preceding complex operation. Let the transformation be required to be made into a series of terms containing ϕx and its differences: let $\phi\,(x+a)-\phi x=\Delta\phi x$, then $\mathrm{E}-1$ is Δ, or $\mathrm{E}=1+\Delta$. But $f\mathrm{E}$ or $f\,(1+\Delta)$ is $\mathrm{B}_0+\mathrm{B}_1\Delta+\mathrm{B}_2\Delta^2+\,\ldots.$ where B_0, B_1, &c. are the values of fy and its successive differential coefficients when $y=0$, divided by 1, 1, 1.2, 1.2.3, &c. Consequently the preceding series is the same as $\mathrm{B}_0\phi x+\mathrm{B}_1\Delta\phi x+\mathrm{B}_2\Delta^2\phi x+\ldots.$ For instance, let the series be $\phi x-\phi\,(x+a)+\phi\,(x+2a)\ldots$ or $(1-\mathrm{E}+\mathrm{E}^2-\ldots.)\,\phi x$ or $(1+\mathrm{E})^{-1}\,\phi x$. Write $1+\Delta$ for E, and we have $(2+\Delta)^{-1}\,\phi x$ or

$$\left(\frac{1}{2}-\frac{1}{4}\,\Delta+\frac{1}{8}\,\Delta^2-\ldots\right)\phi x,\ \text{or}$$

$$\frac{1}{2}\,\phi x-\frac{1}{4}\,\Delta\,\phi x+\frac{1}{8}\,\Delta^2\phi x-\ldots,$$

We have chosen this result as one which is very easy to verify. Let ϕx, $\phi\,(x+a)$, &c., be denoted by X_0, X_1, &c., then [DIFFERENCES] we have

$$\phi x=\mathrm{X}_0,\ \Delta\phi x=\mathrm{X}_1-\mathrm{X}_0,\ \Delta^2\phi x=\mathrm{X}_2-2\mathrm{X}_1+\mathrm{X}_0,$$
$$\Delta^3\phi x=\mathrm{X}_3-3\mathrm{X}_2+3\mathrm{X}_1-\mathrm{X}_0,\ \text{\&c.}$$

Substitute these in $\frac{1}{2}\,\phi x-\frac{1}{4}\,\Delta\phi x+\ldots$, and we have $\frac{1}{2}\,{}_0-\frac{1}{4}$ $(\mathrm{X}_1-\mathrm{X}_0)+\ldots.$: take a few terms, developing the fractions multiplication, and we shall find the preceding to be identical with

$$\left(\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\ldots\right)\mathrm{X}_0-\left(\frac{1}{4}+\frac{2}{8}+\frac{3}{16}+\ldots\right)\mathrm{X}_1+$$
$$\left(\frac{1}{8}+\frac{3}{16}+\frac{6}{32}+\ldots\right)\mathrm{X}_2-\ldots.\ \text{or}$$
$$\frac{1}{2}\left(1-\frac{1}{2}\right)^{-1}\mathrm{X}_0-\frac{1}{4}\left(1-\frac{1}{2}\right)^{-2}\mathrm{X}_1+\frac{1}{8}\left(1-\frac{1}{2}\right)^{-3}\mathrm{X}_2-$$

or $\mathrm{X}_0-\mathrm{X}_1+\mathrm{X}_2-\ldots$ or $\phi x-\phi\,(x+a)+\phi\,(x+2a)-\ldots$

We shall now take an example of interpretation. Required the meaning of Δ^{-1} by means of E? Since $\Delta=\mathrm{E}-1$, we have $\Delta^{-1}=(\mathrm{E}-1)^{-1}=\mathrm{E}^{-1}+\mathrm{E}^{-2}+\mathrm{E}^{-3}+\ldots.$ or

$\Delta^{-1}\,\phi x$ means $\phi\,(x-a)+\phi\,(x-2a)+\,\ldots.$ *ad infinitum.*

This is easily shown to be consistent with the relation $\Delta\Delta^{-1}=1$ or $\Delta\Delta^{-1}\,\phi x=\phi x$, for if the preceding series be called ψx, we have $\Delta\Delta^{-1}\phi x=\Delta\psi x=\psi\,(x+a)-\psi x=(\phi x+\phi(x-a)+\,\ldots.)-(\phi(x-a)+\phi(x-2a)+\ldots.)=\phi x$. We have thus obtained and verified one of the infinite number of forms which $\Delta^{-1}\,\phi x$ may represent.

As yet we have nothing which might not have been done with tolerable ease by common methods, nor shall we have done more in proving Taylor's Theorem, but the step which we shall make to follow that proof will be an instance of the deduction of a theorem which is of a more difficult character.

Let $(\phi(x+\theta)-\phi x)$: θ be called D_θ: then the smaller θ becomes, the more nearly is $\mathrm{D}_\theta\phi x$ the differential coefficient of ϕx, or $\phi' x$. Let θ be the nth part of the given quantity a: then the smaller θ is, the greater must n be. We have then

$$\phi\,(x+\theta)=(1+\theta\mathrm{D}_\theta)\,\phi x,$$
$$\phi\,(x+2\theta)=(1+\theta\mathrm{D}_\theta)^2\,\phi x,\ \text{since}$$
$$\phi\,(x+2\theta)-\phi\,(x+\theta)=\theta\mathrm{D}_\theta\phi\,(x+\theta)\ \text{or}$$
$$\phi\,(x+2\theta)=(1+\theta\mathrm{D}_\theta)\,\phi\,(x+\theta)=(1+\theta\mathrm{D}_\theta)^2\,\phi x.$$

Proceeding in this way we obtain $\phi\,(x+n\theta)$ or $\phi\,(x+a)=(1+\theta\mathrm{D}_\theta)^n\,\phi x$ $=\phi x+n\theta\mathrm{D}_\theta\phi x+n\,\dfrac{n-1}{2}\,\theta^2\mathrm{D}^2_\theta\phi x+\ldots.$ For $n\theta$ write a, and the preceding becomes

$$\phi x+a\mathrm{D}_\theta\phi x+a\,\frac{a-\theta}{2}\,\mathrm{D}^2_\theta\phi x+\ldots.$$

which being always $=\phi\,(x+a)$, has a limit also $=\phi\,(x+a)$. Take that limit by diminishing θ without limit, and we see that $\mathrm{D}_\theta\phi x$, $\mathrm{D}^2_\theta\phi x$, &c., become $\phi' x$, $\phi'' x$, &c., or

$$\phi\,(x+a)=\phi x+\phi' x.a+\phi'' x\,\frac{a^2}{2}+\ldots.$$

which is Taylor's Theorem. Suppose we denote the operation of differentiation by D, and $\phi\,(x+a)-\phi x$ by $\Delta\phi x$, we have then

$$1+\Delta=1+a\mathrm{D}+\frac{a^2}{2}\,\mathrm{D}^2+\ldots.=\epsilon^{a\mathrm{D}};$$

a particular case of which (when $a=1$) was chosen as our illustration at the beginning of this article. This relation $1+\Delta=\epsilon^{a\mathrm{D}}$ gives us a great power of converting series which contain differences into those containing differentials, and *vice versâ.*

We now propose to interpret D^{-1}. This symbol must satisfy $\mathrm{D}\mathrm{D}^{-1}\,\phi x=\phi x$, and $\mathrm{D}^{-1}\,\mathrm{D}\phi x=\phi x$, the first of which is satisfied by $\mathrm{D}^{-1}\phi x=\int\phi x\,dx+\mathrm{C}$, where C may have any constant value: but the second is only satisfied by $\int\phi x\,dx$, beginning at a value of x which maks $\phi x=0$. We shall however see that we need not enter on this question in reference to the theorem immediately following.

Let it be required to express $\Delta^{-1}\phi x$, or $\phi(x-a)+\phi(x-2a)+\ldots$ *ad inf.*, by means of operations of the differential and integral calculus.

Since Δ is $\epsilon^{a\mathrm{D}}-1$, we have to find $(\epsilon^{a\mathrm{D}}-1)^{-1}$ expanded in powers* of D. Now common algebraical processes show that $(\epsilon^{t}-1)^{-1}$ can be developed in the series

$$\frac{1}{t}-\frac{1}{2}+\mathrm{B}_1\frac{t}{2}-\mathrm{B}_3\frac{t^3}{2.3.4}+\mathrm{B}_5\frac{t^5}{2.3.4.5.6}-\text{\&c.},$$

where B_1, B_3, B_5, &c., are the NUMBERS OF BERNOULLI, of which an ample stock is given in the article cited: thus $\mathrm{B}_1=\frac{1}{6}$, $\mathrm{B}_3=\frac{1}{30}$, &c. Write $a\mathrm{D}$ for t, restoring ϕx, and for $\mathrm{D}\phi x$, &c., write $\phi' x$, &c. but for $\mathrm{D}^{-1}\phi x$ write $\int\phi x dx+\mathrm{C}$. We have then

$$\phi(x-a)+\phi(x-2a)+\phi(x-3a)+\ldots\textit{ ad infin.}$$
$$=\frac{1}{a}\int\phi x dx+\mathrm{C}-\frac{1}{2}\phi x+\frac{\mathrm{B}_1 a}{2}\phi' x-\frac{\mathrm{B}_3 a^3}{2.3.4}\phi''' x+\ldots.$$

The determination of the constant might in many cases be troublesome, but if we only want a finite number of terms of the series, we can avoid it altogether as follows. Let $x-na=y$, and suppose that $\phi(x-a)+\ldots.$ ending with $\phi(x-na)$ is sought. Write y instead of x in the preceding, remembering that $y-a=x-(n+1)a$, &c.: subtract the result thus obtained from the preceding, and we have

$$\phi(x-a)+\phi(x-2a)+\ldots.+\phi(x-na)$$
$$=\frac{1}{a}\int\phi x dx-\frac{1}{a}\int\phi y dy-\frac{1}{2}(\phi x-\phi y)+\frac{\mathrm{B}_1 a}{2}(\phi' x-\phi' y)-\ldots;$$

But $\int\phi x dx-\int\phi x y dy$ is $\int\phi x dx$ taken from y to x, or if $\phi_1 x$ differentiated give ϕx, it is $\phi_1 x-\phi_1 y$. We introduce this process merely to give some idea of the process to the reader who is already master of the result from other sources; and we cannot here explain the reason why one particular form of $\Delta^{-1}\phi x$ is taken.

For further developments of the results of this subject, see the Appendix to the Translation of Lacroix; Herschel's 'Examples of the Calculus of Differences;' Lacroix's large work on the Differential Calculus, vol. iii.; 'Library of Useful Knowledge—Differential Calculus;' a paper by Mr. Murphy in the Phil. Trans. for 1837; and various papers in the numbers of the 'Cambridge Mathematical Journal.' In several of these works further references will be found. Many other references might be given to scattered volumes: but the student will find much collected together in Professor Boole's two recent works on Differential Equations and on Finite Differences. The student may make an attempt at the demonstration of the following theorem a test of his understanding the method which we have explained, and the points of analysis which are most essential as preliminaries. Whatever a may be, the differential coefficient of ϕx is an algebraical equivalent of the following series:

$$\frac{\phi(x+a)-\phi(x-a)}{a}-\frac{\phi(x+2a)-\phi(x-2a)}{2a}$$
$$+\frac{\phi(x+3a)-\phi(x-3a)}{3a}-\ldots.$$

Instead of supposing ϕx, a function of x only, to be th fundamental subject of operations, we might make it $\phi(x, x_{,})$ and suppose E and $\mathrm{E}_{,}$ to represent the operations of changing x into $x+a$ and $x_{,}$ into $x_{,}+a_{,}$. We can only briefly note some of the results of this extension. If D and $\mathrm{D}_{,}$ represent the operations of differentiation with respect to x and to $x_{,}$, we have in

$$\mathrm{E}\mathrm{E}_{,}=\epsilon^{a\mathrm{D}+a_{,}\mathrm{D}_{,}}=1+(a\mathrm{D}+a_{,}\mathrm{D}_{,})+\ldots.$$

the means of obtaining the common extension of Taylor's Theorem to a function of two variables. Again, if we take $\phi x\psi x$, and let D and $\mathrm{D}_{,}$ represent operations of differentiation, which separately affect ϕx and ψx, we have in the development of $(\mathrm{D}+\mathrm{D}_{,})^{n}\phi x.\psi x$, the formula for forming the nth differential coefficient of the product.

We shall conclude by some indication of the principal steps of the application of the calculus of operations to the solution of differential equations and equations of differences.

However much the calculus of operations may throw light upon the character and principles of algebra, it would at one time have been thought unlikely that it should much facilitate actual processes. It does this, nevertheless, and nowhere more than in the subject we are now going to describe. Solutions which by the usual method [VARIATION OF PARAMETERS] would never have been considered fit examples for an elementary work, on account of their complexity, may be represented with ease, and obtained in full with very little trouble.

When rules of algebra are true of the meanings of any symbols, all consequences of the use of these rules, all relations which are legitimate deductions from them, also represent truths. Not that these truths are always intelligible without subsequent interpretation: nor do we mean to say that, in the present state of the science, the interpretations are always attainable. And further, it may happen that theorems can be pointed out, derived from processes in which *some* only, and not *all*, of the fundamental rules of algebra are true. This does not prevent our right to deduce conclusions from such theorems, so long as we use no fundamental rules except those which are true of the expressions in question. For instance, we have seen that the operations of our calculus are not convertible with the operation of multiplying by a function of the variable. Thus if E stand for the direction to change x into $x+1$, Δ for that of forming the difference thence arising, and D for the direction to take the differential coefficient with respect to x, we have no right to say $\mathrm{E}\phi x(\psi x)=\phi x\mathrm{E}(\psi x)$, or $\Delta\phi x(\psi x)=\phi x\Delta(\psi x)$, or $\mathrm{D}\phi x(\psi x)=\phi x\mathrm{D}(\psi x)$; in which ψx is the function operated upon. But, when we thus use another function, ϕx, besides the one operated on, ψx, this convertibility of operations is the only rule of algebra which fails; it is therefore the only one the use of which we must avoid.

The operations E, Δ, and D, are closely connected with $\mathrm{E}+a$, $\Delta+a$, $\mathrm{D}+a$, of which they are particular cases; a being a constant, positive, negative, or nothing. We have

$$(\mathrm{E}-a).\phi x=a^{x+1}\Delta(a^{-x}\phi x)$$
$$(\Delta-a)\phi x=(a+1)^{x+1}\Delta\left((a+1)^{-x}\phi x\right)$$
$$(\mathrm{D}-a)\phi x=\epsilon^{ax}\mathrm{D}(\epsilon^{-ax}\phi x).$$

The first sides of these equations being representatives of $\phi(x+1)-a\phi x$, $\Delta\phi x-a\phi x$, and $\phi' x-a\phi x$. If these operations be repeated, we have

$$(\mathrm{E}-a)^{m}\phi x=a^{x+m}\Delta^{m}(a^{-x}\phi x)$$
$$(\Delta-a)^{m}\phi x=(a+1)^{x+m}\Delta^{m}\left((a+1)^{-x}\phi x\right)$$
$$(\mathrm{D}-a)^{m}\phi x=\epsilon^{ax}\mathrm{D}^{m}(\epsilon^{-ax}\phi x).$$

These results will also be found to be true when m is negative, by which means we are enabled to interpret $(\mathrm{D}-a)^{-1}$, $(\Delta-a)^{-1}$, and $(\mathrm{E}-a)^{-1}$ and their repetitions.

These same forms may be extended, as follows:—Let E_x and E_y severally denote the operations of changing x into $x+1$ and y into $y+1$; and let D_x, D_y, Δ_x, Δ_y, be similarly interpreted with respect to the differentiations and differences. We have then

$$(\mathrm{E}_x-a)^{m}(\mathrm{E}_y-b)^{n}=a^{x+m}b^{y+n}\Delta_x^{m}\Delta_y^{n}a^{-x}b^{-y}$$
$$(\Delta_x-a)^{m}(\Delta_y-b)^{n}=(a+1)^{x+m}(b+1)^{y+n}\Delta_x^{m}\Delta_y^{n}(a+1)^{-x}(b+1)^{-y}$$
$$(\mathrm{D}_x-a)^{m}(\mathrm{D}_y-b)^{n}=\epsilon^{ax+by}\mathrm{D}_x^{m}\mathrm{D}_y^{n}\epsilon^{-ax-by}$$

in which the function first operated upon is left out to save room. Here m and n may be either positive or negative integers. And even a or b may be symbols of operation, but not with respect to x or y. Thus

$$(\mathrm{D}_x-a\mathrm{D}_y)^{m}=\epsilon^{ax\mathrm{D}_y}\mathrm{D}_x^{m}\epsilon^{-ax\mathrm{D}_y},$$

in which the second side is to be thus interpreted. Changing y into $y-ax$, differentiate m times with respect to x, and then change y into $y+ax$.

We shall now give the heads of some methods of solution, observing that this article is intended only for those who can already master the same solutions by other methods.

Take the common linear equation—

$$a\frac{d^{m}y}{dx}+b\frac{d^{m-1}y}{dx^{m-1}}+\ldots=\mathrm{X},$$

in which a and b are constants, and X a function of x. The operation performed upon y is $a\mathrm{D}^{m}+b\mathrm{D}^{m-1}+\ldots$: if this be called G, then y is the result of performing the inverse operation G^{-1} upon X. By the method explained in FRACTIONS, DECOMPOSITION OF, transform $(a\mathrm{D}^{m}+b\mathrm{D}^{m-1}+\ldots)^{-1}$ into $\mathrm{A}(\mathrm{D}-\alpha)^{-1}+\mathrm{B}(\mathrm{D}-\beta)^{-1}+$, &c., where α, β, &c. are the roots of the algebraical equation $ax^{m}+bx^{m-1}+\ldots=0$. Then y is

$$\mathrm{A}(\mathrm{D}-\alpha)^{-1}\mathrm{X}+\mathrm{B}(\mathrm{D}-\beta)^{-1}\mathrm{X}+\ldots$$
$$\text{or }\mathrm{A}\epsilon^{\alpha x}\int\epsilon^{-\alpha x}\mathrm{X}dx+\mathrm{B}\epsilon^{\beta x}\int\epsilon^{-\beta x}\mathrm{X}dx+\ldots.$$

substituting for D^{-1} its usual mode of expression. The arbitrary parts of the solutions will be obtained by the constants of integration in the usual manner. But the arbitrary part may always be obtained, in all inverse operations, by considering the function operated upon as $\mathrm{X}+0$, and operating separately upon X and 0. Thus $(\mathrm{D}-\alpha)^{-3}\mathrm{X}$ may be completely expressed by

$$\epsilon^{\alpha x}\left(\int dx\right)^{3}\epsilon^{-\alpha x}\mathrm{X}+\epsilon^{\alpha x}\left(\int dx\right)^{3}\epsilon^{-\alpha x}0,$$

the second term of which is $\epsilon^{\alpha x}(\mathrm{P}+\mathrm{Q}x+\mathrm{R}x^{2})$, P, Q, and R being any constants.

Suppose that there are equal roots in the above equation, say three roots equal to α. The resolution of the fraction gives terms of the form

$$\mathrm{K}(\mathrm{D}-\alpha)^{-3}+\mathrm{L}(\mathrm{D}-\alpha)^{-2}+\mathrm{M}(\mathrm{D}-\alpha)^{-1},$$

which contribute to the general value of y,

$$\epsilon^{\alpha x}\left\{\mathrm{K}\left(\int dx\right)^{3}+\mathrm{L}\left(\int dx\right)^{2}+\mathrm{M}\int dx\right\}\epsilon^{-\alpha x}\mathrm{X},$$

and the arbitrary part $\epsilon^{\alpha x}(\mathrm{P}+\mathrm{Q}x+\mathrm{R}x^{2})$.

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* We transfer this word, with extension of meaning, to the calculus of operations.

The linear equation of differences corresponding to the above is

$$au_{x+n} + bu_{x+n-1} + \ldots\ldots = \mathrm{X},$$

where u_x is a function of x to be determined. The operation performed on u_x on the first side is $a\mathrm{E}^n + b\mathrm{E}^{n-1} + \ldots$

Every single root a, contributes to the solution a term of the form

$$\mathrm{A}(\mathrm{E} - a)^{-1}.\,\mathrm{X} \text{ or } a^{x-1}\,\Delta^{-1}(a^{-x}\,\mathrm{X}),$$

in which $\Delta^{-1}\,a^{-x}\mathrm{X}$ may be any function of which the difference is $a^{-x}\mathrm{X}$. If x be an integer, what is called $\Sigma\,(a^{-x}\mathrm{X})$ will do. Any set of equal roots contributes terms of the form

$$\mathrm{A}(\mathrm{E} - a)^{-k}\,\mathrm{X} \text{ or } \mathrm{A}a^{x-k}\Delta^{-k}\,(a^{-x}\mathrm{X}).$$

Any linear equation being given, in which either of the operations E_x, Δ_x, or D_x is combined with either E_y, D_y, or D_y, the form of the solution may be found. Take for example

$$\frac{d}{dx}\,u_{x,y} - au_{x,y+1} = \mathrm{X},$$

the operation performed upon $u_{x,y}$ on the first side is $\mathrm{D}_x - a\mathrm{E}_y$, and accordingly we have

$$u_{x,y} = \epsilon^{ax\mathrm{E}_y}\int \epsilon^{-ax\mathrm{E}_y}\,\mathrm{X}dx,$$

which is one form of the solution, and must be interpreted by expanding

$$\epsilon^{\pm ax\mathrm{E}_y} \text{ into } 1 \pm ax\mathrm{E}_y + \frac{1}{2}\,a^2x^2\mathrm{E}_y^2 \pm \ldots$$

Another form can be obtained from

$$\left(\mathrm{E}_y - \frac{1}{a}\,\mathrm{D}_x\right)u_{x,y} = -\frac{1}{a}\,\mathrm{X}.$$

We can only touch very briefly upon these points, and rather to show the existence of the system than to enter into it. Further details will be found in the *Library of Useful Knowledge*, in the 'Treatise on the Differential Calculus,' pp. 751-758.

The theorems answering to that of integration by parts, when $\mathrm{D}-a$ and $\mathrm{E}-a$ are used, are as follows. To save room let $\mathrm{D}-a$ and $\mathrm{E}-a$ be denoted by Θ and Λ. Then

$$\Theta^{-1}\,(\mathrm{PQ}) = \mathrm{P}\Theta^{-1}\,\mathrm{Q} - \Theta^{-1}\left\{\mathrm{P}'\Theta^{-1}\mathrm{Q}\right\}$$

$$\Lambda^{-1}(\mathrm{PQ}) = \mathrm{P}\Lambda^{-1}\mathrm{Q} - \Lambda^{-1}\left\{\Delta\mathrm{P}\,.\,\Lambda^{-1}\mathrm{EQ}\right\}$$

P and Q being functions of x, to which D and E refer, and P′ meaning $d\mathrm{P} : dx$. If $a = 0$, the first becomes

$$\int \mathrm{PQ}dx = \mathrm{P}\int \mathrm{Q}dx - \int\left\{\mathrm{P}'\,.\int \mathrm{Q}dx\,.\,dx\right\},$$

which is the formula for integration by parts. And if Q be of the form $\Theta^n\mathrm{R}$, or $\Lambda^n\mathrm{R}$, and P be a rational and integral function of a lower degree than the nth, the preceding operations carried on will show that $\Theta^{-1}(\mathrm{P}\Theta^n\,\mathrm{R})$ and $\Lambda^{-1}(\mathrm{P}\Lambda^n\mathrm{R})$ can be performed without leaving any trace of inverse operation in the result. Of the first of these it is a particular case that—

$$\int \mathrm{P}\,\frac{d^n\mathrm{R}}{dx^n}\,dx$$

can be found whenever P is a rational and integral function of a lower degree than the nth. Thus, P being of the second degree,

$$\Theta^{-1}(\mathrm{P}\Theta^4\mathrm{R}) = \mathrm{P}\Theta^3\mathrm{R} - \mathrm{P}'\Theta^2\mathrm{R} + \mathrm{P}''\Theta\mathrm{R}$$

$$\Lambda^{-1}(\mathrm{P}\Lambda^3\mathrm{R}) = \mathrm{P}\Lambda^2\mathrm{R} - \Delta\mathrm{P}.\Lambda\mathrm{ER} + \Delta^2\mathrm{P}.\mathrm{E}^2\mathrm{R}.$$

By help of these theorems the intermediate equations of any linear equation can be readily discovered. Suppose, for instance, we have

$$(\mathrm{D}-1)^5(\mathrm{D}-2)^3y = \mathrm{X},$$

an equation of the eighth degree. There are eight equations of the seventh degree. Two of them are discovered at once by performing the operations $(\mathrm{D}-1)^{-1}$ and $(\mathrm{D}-2)^{-1}$ on both sides, giving

$$(\mathrm{D}-1)^4\,(\mathrm{D}-2)^3\,y = \epsilon^x\int \epsilon^{-x}\,\mathrm{X}dx,$$

$$(\mathrm{D}-1)^5\,(\mathrm{D}-2)^2\,y - \epsilon^{2x}\int \epsilon^{-2x}\,\mathrm{X}dx.$$

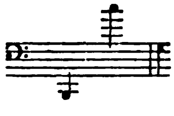
To find the other six, multiply separately by x, x^2, x^3, x^4, the simplest functions of their several degrees, and perform $(\mathrm{D}-1)^{-1}$ upon all four results, and $(\mathrm{D}-2)^{-1}$ upon the first two. This, by the preceding theorems, can be done. Thus, multiplying by x we have

$$(\mathrm{D}-1)^5\left\{x(\mathrm{D}-2)^2y - (\mathrm{D}-2)\,y\right\} = \epsilon^{2x}\int \epsilon^{-2x}\,x\mathrm{X}dx,$$

$$(\mathrm{D}-2)^3\left\{x(\mathrm{D}-1)^4 - (\mathrm{D}-1)^3\,y\right\} = \epsilon^x\int \epsilon^{-x}\,x\mathrm{X}dx,$$

which are two more of the required equations. To find the equations of the sixth degree, those of the seventh degree must be selected which admit of a repetition of the operation without leaving the inverse form $(\mathrm{D}-2)^{-1}y$ or $(\mathrm{D}-1)^{-1}y$: and the operation must be repeated; and so on.

OPHICLEIDE (ὄφις, "a serpent or snake," and κλεὶς, "a key"), a musical instrument of the inflatile kind, made of brass or copper, and intended to supersede the serpent—of which it is a decided improvement—in the orchestra and in military bands. It is a conical tube, the longest nearly 9 feet in length, terminating in a bell, like the horn. It has 10 ventages, or holes, all of which are stopped by keys, similar to those of the bassoon, only of larger dimensions, and is furnished with the same kind of mouth-piece as the serpent. The scale of the base ophicleide is from B, the third space below the base staff, to C, the fifth added space above it,—



including every tone and semi-tone within this compass. Music for the ophicleide is written in the base clef; for the alto, or *ophicleide quint*, in the treble clef. When the two instruments play together, the music for the alto is written an octave higher than that for the base.

The ophicleide was invented some years ago, in Germany. It is too noisy an instrument to be played in any but spacious buildings. There are several varieties of the instrument. In its early form it was used in the military bands of the northern sovereigns, when the troops of the allies occupied Paris. M. Labbaye, a manufacturer of musical instruments in that city, added new keys to it, and otherwise much extended its capabilities; besides which, he discovered a better mode of constructing the tube than had been practised, and thus greatly ameliorated its tone. These improvements were reported to the French Society of Arts in 1821 by M. Francœur, in consequence of which Labbaye obtained a patent for five years. The ophicleide first reached England in 1834, one of extraordinary dimensions having been manufactured abroad for the Birmingham Musical Festival of that year. In the Supplement to the 'Musical Library' for November, 1834, it is thus mentioned: "A new instrument, the *double-base ophicleide*, made for this festival, and now first introduced into England, proved eminently serviceable in the choruses, and whenever strength was required. The volume of sound it emits is immense, but the tone is rich, round, and blends well with the voices. We are much deceived if this instrument is not destined to operate a great change in the constitution of our orchestras: well played, it will answer the purpose of four double-bases, and is well calculated to form a third part to the bassoons, which has long been a desideratum. As a contra-basso to the trombones, it will not be found less useful." This prognostic has proved correct; the instrument is now become indispensable. Examples of its effective and judicious use are to be found in the 'Gloria,' and 'Marche Réligieuse' of Cherubini's third solemn mass, performed at the consecration of Charles X.

OPHIU'CHUS (the Serpent-bearer), one of the old constellations, representing a man holding a serpent, which is twined about him. But the moderns make a separate constellation of the serpent. [SERPENS.] Ophiuchus has also been called Anguitenens and Serpentarius. The figure of the man rests his feet upon the back of Scorpius, and is surrounded by Scorpius, Libra, Bootes, Corona, Hercules, and Aquila. It is not a constellation of any note, containing no star of the first, and only one of the second, magnitude. The number and insignificance of the mythological traditions connected with it are rendered less surprising by this paucity of remarkable stars, since the latter is a presumption that the constellation itself is of a later date than Orion or Ursa Major.

The following is a list of the principal stars:—

Character.	No. in Catalogue of Flamsteed.	No. in Catalogue of British Association.	Magnitude.
δ	1	5414	3
ε	2	5437	3·5
φ	8	5516	4
λ	10	5520	4
ζ	13	5548	3
ι	25	5692	4
κ	27	5708	4
η	35	5781	3
ξ	40	5844	4
θ*	42	5851	4
α	55	5941	2
β	60	5996	3
γ	62	6020	4
ν	64†	6078	4
ο	67	6092	4
k	69	6104	4
	70	6123	4
	72	6143	4

* Does not agree with Bayer.

† 65 of Flamsteed was either a mistake, or has disappeared.

OPHTHALMIA (from *ophthalmos*, ὀφθαλμος, the "eye") is an inflammation of the eye. General ophthalmia, or an inflammation of the whole globe of the eye, is a very rare occurrence. Cases however do occur, from severe injuries or other causes, in which the signs of all the special forms of ophthalmia are combined, and they are the most formidable affections to which the eye is liable. Unless met by the most active antiphlogistic treatment, they usually terminate in complete destruction of the organ.

In the large majority of inflammations of the eye, one part of it is alone or especially affected. Hence there have been described numerous varieties of ophthalmia, a distinct name being formed for the inflammation of each part or tissue by appending the termination *itis* to its anatomical name; as conjunctivitis, iritis, and corneitis, for the inflammations of the conjunctiva, iris, and cornea. [Eye, in Nat. Hist. Div.]

Of all the varieties of ophthalmia, slight inflammation of the conjunctiva is the most frequent. It is the common result of all slightly irritating bodies being introduced between the eyelids, and of the application of cold, in which case it is often called catarrhal ophthalmia. Its symptoms are redness, varying from a pale-pink to a scarlet colour, of the external membrane of the eye and of the lining of the eyelids, the blood-vessels (which are naturally invisible) appearing swollen and tortuous, and making the front of the eye what is commonly called blood-shot; swelling of the eyelids and increased thickness and puffiness of the conjunctiva of the ball; and an increased secretion of opaque white or yellow tenacious mucus which agglutinates the eyelids. The pain is seldom acute, except in severe cases, in which it has a peculiar character, as if there were dust or fine sand rubbing between the eyelids. There is rarely any intolerance of light or any constitutional affection, and the vision is not at all affected, except by the swelling of the eyelids and the accumulated mucus.

In this, the common inflammation of the eyes, no active means need be employed. In severe cases, blood has been taken from the arm; but in general, the application of leeches, cooling lotions applied to the eyes, and mild purgatives or sweating medicines, are sufficient for the removal of the inflammation, which, as it does not affect a part directly important to vision, nor spread beyond the tissue first affected, rarely leaves any inconvenience behind. In the mild cases of this kind, a lotion composed of two grains of sulphate of zinc to the ounce of water is the best, and generally a sufficient remedy; the eyes should be washed with it three times a day.

That which is commonly called purulent ophthalmia is a much more serious form of inflammation of the conjunctiva. It was observed in its greatest severity in the European armies engaged in Napoleon's campaign in Egypt, and is therefore sometimes called Egyptian ophthalmia; and from its appearing to spread from one individual to another by the contact of the purulent matter secreted by the inflamed eyes, it has also received the name of contagious ophthalmia. In this form, which has often appeared as an epidemic, and is generally acknowledged to be liable to spread by contagion, all the symptoms of the preceding are greatly aggravated. The conjunctiva is intensely red, and so swollen that it is raised in a deep ring round the cornea, whose edges it overlaps so as almost totally to obstruct the sight. The conjunctiva of the eyelids is at the same time excessively inflamed, and by effusion into their loose cellular tissue they often become so distended that they completely cover the front of the eye. A considerable quantity of acrid yellow purulent discharge constantly flows between the eyelids, producing excoriations of them and of the cheeks. The pain is often extremely acute, vividly smarting, or hot and burning, and it is accompanied by some intolerance of light. From the conjunctiva, which it at first affects, the purulent ophthalmia often spreads rapidly to the other tissues of the eye; producing ulceration and sloughing, or excessive opacity of the cornea, and all the worst results of inflammation of the several tissues, even to suppuration and destruction of the whole of one or both eye-balls.

The treatment of this form of ophthalmia must be active in proportion to the rapidity of its destructive effects when unchecked. Bleeding, both general and local, may be employed, and purgatives and the various other antiphlogistic means should be administered, as in the treatment of any other acute inflammation. When the inflammation is somewhat checked, the greatest benefit is derived from the application of powerful astringents to the eye, a mode of treatment which may be adopted with equal advantage in these and in the severer cases of catarrhal ophthalmia. The best material is a solution of from two to four grains of lunar caustic to the ounce of water; of which one or two drops should be let fall into the eyes once or twice a day, according to the severity of the inflammation. This remedy produces considerable pain for a short time after its application, but is generally productive of the most beneficial results.

One of the most common effects of the purulent ophthalmia, when prevented by active treatment from producing its worst results, is a thickening and roughness of the inflamed lining of the eyelids, to which the name of granular conjunctiva is given. The affected surface looks like that of a florid ulcer, and the friction of its irregularities upon the front of the eye-ball keeps up a constant slight inflammation, of which the common consequence is a complete opacity of the cornea. The granular conjunctiva may be treated by the application of powerful astringents or caustics; the most efficient, though a severe remedy, is to touch the rough surface with a piece of sulphate of copper, taking care after its application that no considerable portion of it comes in contact with the front of the eye.

Infants of three or four days old are often the subjects of a very severe form of inflammation of the conjunctiva, to which the name of the ophthalmia of new-born children has been given. Its course and effects are similar to those just described, and it sometimes produces entire destruction of the eye before it attracts proper attention, for the eyelids are commonly agglutinated together by the discharge, and are so swollen that they obscure the front of the eye. Its severest form may be suspected when the upper eyelid is much swollen and is externally of a bright red colour. The treatment must be similar in its principles to that for the corresponding disease in the adult; in severe cases a leech should be applied to the temples, and purgatives should be administered in all; and when the inflammation is somewhat relieved, or from the first, if it be not very severe, astringent lotions should be dropped into the eyes. The best form is composed of from two to ten grains of alum in an ounce of water, beginning with the smaller quantity and gradually increasing the strength.

Another form of inflammation of the conjunctiva is that called strumous ophthalmia. It occurs in children of scrofulous habit, and is chiefly remarkable for the extreme intolerance of light by which it is accompanied. The patient cannot be induced to open the eyes, or even to raise them to the light, but keeps his head down, with the eyelids pressed together upon the ball of the eye, and carefully covered with his hands or his clothes. The degree of inflammation is by no means proportionate to the severity of this symptom; the conjunctiva is usually only a little reddened, but in many cases little pustular elevations form upon the edges of the cornea. The treatment of these cases should be chiefly that adapted for the constitutional disorder on which their peculiarities depend. [Scrofula.] Pure air and exercise, mild aperients and tonics, and especially bark, iodine, and iron should be administered, and the general health should be carefully attended to. In the earlier stages a few leeches may be applied, but afterwards counter-irritation by blisters placed behind the ears, or by tartar-emetic ointment rubbed on the same parts, is most useful. Slightly astringent lotions may also be applied to the eyes, and the ulcers or little pustules on the cornea touched with the solid nitrate of silver (lunar caustic).

The characters of inflammation of the sclerotica are very different from those of inflammation of the conjunctiva, but very often the two affections are coincident, so that the appearances belonging to each are confounded. In sclerotitis, as this form of ophthalmia is sometimes called, the redness of the eye has a rose-pink or violet tinge, rather than the scarlet hue which is seen in the preceding form; for the distended vessels are fewer and smaller, and are to a certain extent obscured by the conjunctiva, beneath which they lie. This redness is most intense in a zone around the cornea, at which the enlarged vessels are concentrated like rays, and from whose outer border the redness diminishes in brightness till it is nearly lost at the angles of the eye; and by this circumstance sclerotitis is further distinguished from inflammation of the conjunctiva, in which the redness increases with the distance from the cornea. In sclerotitis there is always considerable pain of a dull heavy kind, which often extends all round the orbit, or over the forehead and head, and is accompanied by intolerance of light and a profuse secretion, not of mucus or pus, as in the preceding cases, but of hot tears. The pain is very often aggravated in the evening, or throughout the night.

The treatment of inflammation of the sclerotica must, as far as general means are concerned, be the same as for acute inflammation of the conjunctiva. The application of astringents or stimulants is useless, and sometimes injurious; the vapour of hot water and other warm fomentations are the local means which are most agreeable to the patient. The moderate use of mercury is generally useful. In rheumatic and gouty conditions of the system, with which this form of ophthalmia is often connected, and is then called rheumatic or arthritic ophthalmia, the treatment adapted to the general disorder should, as far as possible, be combined with those means which are proper for the local disease. [Gout; Rheumatism.]

Inflammation of the cornea, corneitis, or keratitis, is very generally connected with some degree of the preceding. Its signs are those which are common to the inflammations of all the deep-seated tissues, namely, dull pain, intolerance of light, and profuse discharge of hot burning tears; at the same time a few vessels passing inward from the red zone around the cornea become visible upon its surface; it loses its transparency and becomes hazy, or assumes a grayish and often opaque chalky-white hue, from the deposition of lymph between its laminæ. [Leucoma.] In very severe cases suppuration takes place in the cornea, and it acquires a yellow colour and ulcerates; or matter is poured into the anterior chamber [Hypopium], or the cornea is perforated by ulcers and the iris protrudes; or it sloughs and becomes soft and weak, so that staphyloma is produced.

The treatment of corneitis in its active state is the same as that for inflammation of the sclerotica. After the inflammation is subdued, its effects (which the situation of the cornea renders peculiarly important) admit of but little useful treatment. The opacity which remains, when it is superficial, is usually gradually removed, and that process may be in some degree assisted by the application of a weak solution of nitrate of silver or some other stimulant; the ulcerations generally proceed best when left to themselves, the chasms which they leave being gradually filled up, and the yellow tinge of the cornea which accompanies them being exchanged for a gray or bluish colour; the more serious effects, such as staphyloma, extensive leucoma, sloughing, protrusion of the iris, &c., are irremediable.

Inflammation of the iris has already been treated of. [Iritis.]

Inflammation of the membrane of the aqueous humour is not uncommon in young persons; it is marked by dullness and haziness of the cornea (which is surrounded by the vascular red zone formed by the distended vessels of the sclerotica), an alteration in the colour of the iris, which assumes a dull reddish hue and a turbid or purulent appearance of the aqueous humour, with, in some cases, hypopium. The proper treatment does not differ essentially from that of inflammation of the iris or sclerotica, with which this form of ophthalmia, like all the affections of the deep-seated tissues of the eye, is very generally conjoined.

The inflammations of the parts of the eye which are still more deeply seated are much rarer than any of the preceding; their symptoms also are more obscure, and they are seldom found uncombined with those of some other form of ophthalmia. Their signs are similar to those of the inflammations of the sclerotica and cornea; but the intolerance of light and the loss of vision are usually greater than would arise from the degree of inflammation which exists in the visible tissues. The treatment must be similar to that for the acute inflammation of the iris or cornea, and be actively administered; for the nature of the parts affected renders the least disorganisation of them of the highest importance.

All kinds of ophthalmia may either become chronic after having existed for some time as acute diseases, or may be chronic from their commencement. Their symptoms in either case differ only in degree from those of the corresponding acute forms, and the treatment of them should be the same in principle, though less active. Counter-irritation by blisters or other means, applied to the neighbourhood of the eyes, or setons in the back of the neck, are among the most useful means; and to the milder forms of astringent lotions some preparation of opium, as the *vinum opii*, may be added with advantage.

OPIANIC ACID. [Opium, Alkaloids of.]

OPIANINE. [Opium, Alkaloids of.]

OPIANO-SULPHUROUS ACID. [Opium, Alkaloids of.]

OPIANYL. [Opium, Alkaloids of.]

OPICI. [Osci.]

OPIUM, ALKALOIDS OF. Opium—the dried juice that exudes from incisions made in poppy heads while still growing on the plant—owes its well-known narcotic properties to certain organic bases or alkaloids. The number of these alkaloids at present known is seven; their names are—1. *Morphine;* 2. *Codeine;* 3. *Thebaine;* 4. *Papaverine;* 5. *Opianine;* 6. *Narcotine;* 7. *Narceine.* They exist in opium chiefly in combination with Meconic Acid, and associated with them are *opianyl* [Meconin], resinous matter, caoutchouc, fat, gum, volatile oil, lignin, and small quantities of inorganic salts. The following table exhibits the per-centage composition of four varieties of Smyrna (the best) opium, analysed by Mülder in the year 1836, and consequently before thebaine, papaverine, and opianine were rescued from the ill-defined matter called "gummy extractive:"—

	1.	2.	3.	4.
Morphine . .	10·842	4·106	9·852	3·800
Narcotine . .	6·808	8·150	9·360	6·546
Codeine . .	0·678	0·834	0·848	0·620
Narceine . . .	6·662	7·506	7·684	13·240
Meconine . .	0·804	0·846	0·314	0·608
Meconic acid . .	5·124	3·968	7·620	6·644
Fat . . .	2·166	1·350	1·816	1·508
Caoutchouc . .	6·012	5·026	3·674	3·206
Resin . . .	8·582	2·028	4·112	1·834
Gummy extractive	25·200	31·470	21·834	25·740
Gum . . .	1·042	2·896	0·698	0·896
Mucus . . .	19·086	17·098	21·068	18·022
Water . . .	9·846	12·226	11·422	14·002
Loss . . .	2·148	2·496	0·568	3·334
	100·000	100·000	100·000	100·000

The morphia is however sometimes present to the extent of twelve, and in some French opium prepared in different parts of the Somme department even twenty to twenty-two, per cent. Constantinople opium varies somewhat, but is usually as rich in alkaloids as Smyrna opium, while Persian opium is generally poor in alkaloids, and Indian opium midway, in that respect, between the Smyrna and Persian varieties.

Separation of the opium principles from each other.—The methods by which any single constituent of opium is extracted are tolerably easy; the isolation of each one, however, from the same specimen of opium is a matter of far greater difficulty, and can only be successfully carried out by working with large quantities of raw material. Fortunately the operation is seldom or never necessary, and will only be given here as an illustration of the relations which the principles bear to each other. The following outline of the method adopted, is abridged from Miller's 'Chemistry,' vol. iii., p. 277.

Three pounds of opium are exhausted with water; from the insoluble residue *narcotine* may be extracted by digesting in acetic acid, precipitating with ammonia, and purifying with animal charcoal; from the evaporated infusion, neutralised with chalk, *meconic acid* is precipitated by chloride of calcium, and the meconate of lime farther treated as described under Meconic acid; the clear liquid filtered from the meconate of lime yields crystals of hydrochlorate of *morphine* on being concentrated; farther concentration of the liquid just named causes hydrochlorates of morphine and codeine to crystallise out, from which *codeine* is dissolved out by ammonia and afterwards reprecipitated by potash; ammonia added to the black mother liquor filtered from the hydrochlorates of morphine and codeine precipitates *thebaine* and *papaverine*, which are subsequently separated from each other by basic acetate of lead, while *narceine* and *meconin* remain in the ammoniacal solution; from the latter, narceine is precipitated by acetate of lead, and meconin then alone remains dissolved. *Opianine* has hitherto only been found in Egyptian opium.

1. *Morphine* ($C_{34}H_{19}NO_6 + 2Aq.$), *Morphia, Morphina.* This alkaloid derives its name from *Morpheus*, the god of sleep, in allusion to its narcotic properties. It was probably known during the 17th century, as Ludwig notices, in 1688, a substance called *magistery of opium*, possessing properties similar to those of the body in question. Morphine is found only in plants of the poppy tribe [Papaver, in Nat. Hist. Div.], and is generally combined with meconic acid, but sometimes with sulphuric acid.

Morphine may be extracted from opium in several ways. The 'London Pharmacopœia' directs that the opium be thoroughly exhausted with water, and chloride of lead added to the resulting strained liquor until no more precipitate of meconate of lead is thrown down; the filtrate is then evaporated to the crystallising point, the crystals of hydrochlorate of morphine purified from colouring matter by digesting with animal charcoal and recrystallisation, and morphine precipitated from the hydrochlorate by addition of ammonia.

Robinson's process, modified by Gregory, somewhat resembles that just described, but the aqueous infusion is first neutralised with carbonate of lime, and chloride of calcium is then used in the place of chloride of lead.

Mohr and Thiboumêry's method is based on the solubility of morphine, and insolubility of the other bases, in lime water. It consists in thoroughly exhausting the opium by boiling two or three times in water, gradually adding the resulting decoction to boiling diluted milk of lime, filtering, evaporating, and neutralising the lime by chloride of ammonium, and finally purifying the morphine thus precipitated by treatment with animal charcoal and recrystallisation.

Estimation of morphine. M. Fordos has recently (1857) published a process for determining the amount of morphine contained in any specimen of opium. A weighed quantity is macerated with water for twenty-four hours, the insoluble portion triturated in a mortar, thrown on a filter, and washed three or four times with water. The whole of the liquors are then mixed together, and a third part of them treated gradually with ammônia until, after brisk agitation, a slight ammoniacal odour is perceptible; by this operation the quantity of ammonia necessary for the precipitation of the whole of the bases is known; the latter cannot, however, be at once collected, as much resinous and colouring matter is also thrown down by the ammonia. The next step therefore is to add an equal volume of alcohol to the remaining two-thirds of the mixed liquors, and then double the quantity of ammonia used with the one-third. The alcohol has the effect of keeping in solution all the resin and colouring matter; and although it retards the precipitation of the morphine, the whole of that alkaloid goes down in crystals after standing for three days, and may be collected on a tared filter, washed with ether and chloroform to separate narcotine, and finally weighed. The amount of opium recommended to be operated upon is fifteen grammes (231½ grains).

Morphine is colourless and inodorous, but has a persistent bitter taste. It crystallises in transparent prisms, is soluble in one thousand parts of cold, and four hundred of boiling, water. It is readily soluble in boiling alcohol, but insoluble in ether or chloroform; ammonia also dissolves it slightly. Its alcoholic solution communicates powerful left-handed rotation to a polarised ray. Heated, it parts with its water of crystallisation, melts, and on cooling solidifies into a radiated crystalline mass.

Morphine is exceedingly poisonous. It is a powerful base, combining with acids to form a well marked series of crystalline salts, of which the hydrochlorate and acetate are extensively used in medicine.

Hydrochlorate of morphine ($C_{34}H_{19}NO_6, HCl, + 6Aq.$), frequently called *muriate of morphia*, is a colourless, inodorous, bitter salt, which crystallises in plumose acicular crystals: it is soluble in 16 to 20 times its weight of water; and when boiling water is saturated with it, a crystalline mass is formed as it cools; it is also dissolved by alcohol. When exposed to a red heat, it is totally decomposed and dissipated. Its preparation from opium has already been described.

Acetate of morphine is prepared by dissolving the alkaloid in acetic acid, and evaporating the solution so that crystals may form; these are not however very readily procured, and by the evaporation of the solution a part of the acid is sometimes dissipated, and a portion of the acetate, suffering partial decomposition, is rendered insoluble in water.

The crystals are in the form of colourless radiating needles, which are very readily dissipated by exposure to heat and, like the other salts of morphine, are decomposed by ammonia, potash, and soda, the morphine being precipitated. Acetate of morphine is slightly deliquescent.

Meconate of morphine, which is the natural salt existing in opium, does not crystallise; it is soluble in water and in alcohol.

Sulphate of morphine ($C_{34}H_{19}NO_6, HO, SO_3 + 5Aq.$) crystallises in needles grouped in bundles; it is soluble in about twice its weight of water.

Bisulphate of morphine is procured by supersaturating the neutral salt with sulphuric acid; the excess of acid is to be removed by ether, which does not dissolve the bisalt.

Nitrate of morphine is obtained by dissolving the alkaloid in the acid; it assumes at first a fine deep orange colour, which afterwards becomes yellow, and, by the continued action of the nitric acid, oxalic acid is procured; when however dilute acid is used, a neutral salt is procured in the form of stellated crystals. It is soluble in 1½ part of water.

Phosphate of morphine crystallises in cubes, or in radiating bundles, when the acid is in excess.

Tartrate of morphine contains ($2\,C_{34}H_{19}NO_6, C_8H_6O_{12}, + 6Aq.$), and *bitartrate of morphine* ($C_{34}H_{19}NO_6, C_8H_6O_{12} + Aq.$). The *citrate* is said to be the morphine salt contained in "*black drop.*"

Sulphomorphide ($C_{68}H_{36}N_2O_{16}S_2$) containing the elements of sulphate of morphine less four atoms of water, is an amorphous substance produced by the action of excess of dilute sulphuric acid upon morphine: if binoxide of lead is also present a brown uncrystallisible matter termed *morphetin* results.

Iodomorphine ($C_{34}H_{19}NO_6, I_3$?). Obtained on triturating together equal parts of iodine and morphine, or on adding iodine to solution of sulphate of morphine and heating. It has a red-brown colour.

Methyl-morphine ($C_{34}H_{18}(C_2H_3)NO_6$) and *ethyl-morphine* ($C_{34}H_{18}(C_4H_5)NO_6$) are obtained as crystalline hydriodates by acting upon morphine with the iodides of methyl and ethyl respectively.

The general properties of the salts of morphine and the means of detecting their presence are as follow:—when nitric acid is dropped on crystallised morphine, a bright red or orange colour is the result; when morphine or one of its salts is acted on by a neutral solution of sesquioxide or sesquichloride of iron, a fine blue colour is the result, which disappears when an excess of acid is added, and reappears when the latter is saturated. Lassaigne proposes to detect the presence of the salts of morphine by evaporating the suspected solution at a temperature of 212°: the residue treated with alcohol dissolves the salt of morphine, and probably some other matters which may have been mixed with it; by spontaneous evaporation of the alcoholic solution the salt of morphine crystallises; from this, redissolved, ammonia throws down a precipitate which is recognised to be morphine by its bitter taste, alkalinity, solubility in alcohol, &c. Vegetable alkaloids as a general rule combine with iodic acid to form iodates; but when a solution of iodic acid is brought into contact with morphine or its salts, the liquid assumes a reddish brown colour, and exhales the peculiar smell of iodine, the presence of which may be detected by starch. According to Serullas, who proposed this test, a grain of morphine in 7000 grains of water may be detected by it.

2. *Codeine* ($C_{36}H_{21}NO_6 + 2\,Aq.$). This alkaloid derives its name from the Greek word *κώδη, a poppy head,* in allusion to its natural source. It exists in opium in far smaller quantity than morphine, the amount varying from two to eight parts in one thousand. Large quantities of it are, however, obtained as a bye-product in the preparation of morphine, and as a substitute for that alkaloid, it has of late years been much used on the continent. It readily crystallises on evaporating the liquors from which morphine has been precipitated by ammonia.

Codeine crystallises in large, colourless rhombic octohedra. It is soluble in eighty parts of cold, and seventeen of boiling water, and is also freely soluble in alcohol and in ether. Its solutions possess powerful lævo-rotation.

The salts of codeine are as great in number as those of morphine, and are even more readily obtained in large crystals: their constitution is also very similar. Iodide of ethyl combines with codeine to form hydriodate of *ethyl-codeine* ($C_{36}H_{20}(C_4H_5)NO_6$). Chlorine, bromine, and peroxide of nitrogen respectively give *chlorocodeine* ($C_{36}H_{20}ClNO_6 + 3Aq$), *bromocodeine* ($C_{36}H_{20}BrNO_6 + Aq.$) and *nitrocodeine* ($C_{36}H_{20}(NO_4)NO_6$). *Tribromocodeine* ($C_{36}H_{18}Br_3NO_6$) has also been obtained; and *iodocodeine* ($C_{36}H_{21}NO_6, I_3$) by a process similar to that for preparing *iodomorphine*. *Di-iodocodeine* ($C_{36}H_{19}I_2NO_6$) is a yellow crystalline precipitate formed on adding chloride of iodine to a strong solution of hydrochlorate of codeine. Cyanogen passed into a strong alcoholic solution of codeine is absorbed and after a time brilliant hexagonal plates of a new base *Cyanocodeine* ($C_{40}H_{21}N_3O_6 = C_{36}H_{21}NO_6, Cy_2$) are deposited. Cyanocodeine forms crystalline salts with acids.

3. *Thebaine* ($C_{38}H_{21}NO_6$), so called from *Thebes*, an ancient city of Egypt, the alkaloid having probably been first obtained from Egyptian opium. Pelletier thought it only an isomeric modification of morphine, and hence called it *paramorphine*. Its position among, and the method of its separation from, the other alkaloids, have already been indicated. It is not, like papaverine, precipitated from solution by subacetate of lead, but on separating the lead by sulphuric acid and adding slight excess of ammonia; it is then thrown down, and may be rendered colourless by treatment with animal charcoal and recrystallisation from alcohol.

Thebaine crystallises in colourless square plates of silvery lustre and acrid, styptic taste. It is insoluble in alkalies and in water, but readily so in alcohol or ether. It melts at 257° Fahr., and at a higher temperature is decomposed; is coloured red by sulphuric acid; rapidly attacked by nitric acid; with acids forms salts that crystallise with difficulty, or not at all; and, finally, is very poisonous.

4. *Papaverine* ($C_{40}H_{21}NO_8$). This base was discovered by Dr. Merck in 1848. It is separated from the lead compound already mentioned, by digesting in alcohol, filtering, distilling off the alcohol, treating the residue with hydrochloric acid, again filtering, evaporating, and setting aside, when hydrochlorate of papaverine gradually crystallises out.

Papaverine occurs in confused aggregated, acicular, white crystals. It is tolerably soluble in hot alcohol or ether, but insoluble in water. In contact with great excess of hydrochloric acid it separates in oily drops, and collects as a layer at the bottom of the vessel, but this layer gradually solidifies into a mass of crystals. Papaverine differs from the other opium alkaloids in giving a blue colour with strong sulphuric acid. The salts that it forms with acids are mostly difficultly soluble in water, and do not appear to be very poisonous.

5. *Opianine* ($C_{66}H_{36}N_2O_{21}$). This alkaloid seems to exist only in Egyptian opium, and occurs along with the morphine prepared from that variety of the drug. It is less soluble in alcohol than morphine and may therefore be separated by crystallisation. It forms long, colourless, transparent, brilliant needles; is precipitated from its solutions by ammonia as a white impalpable powder; is insoluble in water and cold alcohol, and not very soluble in boiling alcohol, the solution possessing a marked alkaline reaction, powerfully bitter taste, and is apparently as poisonous as an equally strong solution of morphine. The hydrochlorate forms double salts with the chlorides of platinum and mercury. Opianine is unaltered by strong sulphuric acid; is turned yellow by nitric acid; and blood-red changing to yellow by sulphuric acid containing nitric acid. It much resembles narcotine.

6. *Narcotine* ($C_{46}H_{25}NO_{14} + 2Aq.$) derives its name from the Greek *ναρκωτικὸς, narcotic;* its narcotic properties are, however, far inferior to those of morphine. It is extracted from that part of the opium that remains insoluble after exhaustion with water, by treating with dilute acetie or hydrochloric acid, and precipitating the filtrate with ammonia; the precipitate digested in boiling alcohol, filtered and allowed to cool, deposits the narcotine in crystals.

Narcotine occurs in opium to the extent of six to eight per cent. It crystallises in colourless right rhombic prisms, inodorous, but of bitter taste. It is insoluble in cold water; only soluble in seven thousand parts of boiling water; insoluble in caustic alkalies, but soluble in ether, alcohol, and the fixed and essential oils. Its alcoholic solution exerts lævo-rotation on polarised light, but dextro-rotation if excess of an acid is present. It is coloured blood-red by sulphuric acid containing nitric acid. By heat it fuses and gives off water, and at a higher temperature than 340° Fahr. is decomposed.

Narcotine combines with some of the acids, but the resulting salts are somewhat unstable and crystallise with difficulty. The *chloroplatinate* contains ($C_{46}H_{25}NO_{14}, HCl, PtCl_2$). The *sulphate* is decomposed, when boiled with dilute sulphuric acid, into a dark green amorphous powder termed *sulphonarcotide* ($C_{92}H_{48}N_2S_2O_{34}$), that is to say, the elements of neutral sulphate of narcotine less four atoms of water: if some binoxide of lead is also present a brown amorphous alkaloid termed *narceine* results.

Narcotic acid is produced as an oleaginous potash salt, on boiling narcotine for some time with strong caustic potash.

Humopic acid is a dark brown amorphous body formed on heating narcotine in an oil bath to a few degrees above its fusing point.

Cotarnine ($C_{26}H_{13}NO_6 + 2\,Aq.$) is produced when narcotine is acted upon by oxidising agents. It forms starry groups of colourless needles, slightly soluble in cold water, more so in hot water, insoluble in potash, but soluble in alcohol, ether, and ammonia. It readily combines with acids to form salts. The *hydrochlorate* contains ($C_{26}H_{13}NO_6, HCl, + 5\,Aq.$), and crystallises in long silky needles.

Opianyl ($C_{20}H_{10}O_8$) (Gerhardt's *hydride of opianyl* ($C_{20}H_9O_8, H$), accompanies cotarnine under the circumstances just mentioned. It is identical with the meconin that exists naturally in opium. It occurs in acicular crystals. Nitric acid converts into *hyponitromeconic acid*, or *nitromeconin*. [MECONIN.]

Apophyllic acid ($C_{16}H_7NO_8$), so called from the resemblance of its crystals to those of the well known mineral *apophyllite*, is produced by the breaking up of cotarnine on prolonging the oxidation of narcotine; the opianyl is also then broken up into hemipinic and opianic acids.

Hemipinic acid ($C_{20}H_{10}O_{12} + 4\,Aq.$) crystallises in colourless rhomboidal prisms. It is volatile and condenses in brilliant plates. *Ethyl-hemipinic acid* contains ($C_{20}H_9(C_4H_5)O_{12} + 3\,Aq.$).

Opianic acid ($C_{20}H_{10}O_{10}$) (Gerhardt's *hydrated oxide of opianyl* $\left.\begin{matrix}C_{20}H_9O_8, O\\ H\,O\end{matrix}\right\}$) is a tolerably abundant product of the energetic oxidation of narcotine. It crystallises in small, shining, silky prisms; is slightly soluble in cold water, more so in hot water, and also in alcohol;

reacts as an acid; readily melts but does not appear to be volatile. The lead and silver salts occur in thin shining prisms and flakes. Sulphurous acid converts it into *opiano-sulphurous acid* ($C_{20}H_8O_8, S_2O_4$?).

Sulphopinic acid ($C_{20}H_{10}O_8S_2$) (Gerhardt's *sulphide of opianyl* $\left.\begin{matrix} C_{20}H_9O_8, S \\ H\,S \end{matrix}\right\}$) is produced on passing sulphuretted hydrogen into a solution of opianic acid kept at a temperature of about 158° Fahr. It crystallises from alcohol in slender needles.

Opiammon ($C_{40}H_{19}NO_6$), (Gerhardt's *nitride of opianyl and hydrogen* $N\left\{\begin{matrix} C_{20}H_9O_8 \\ C_{20}H_9O_8 \\ H \end{matrix}\right.$) is a pale yellow crystalline powder obtained on evaporating a solution of opianate of ammonia. Caustic potash partly converts it into *xanthopenic acid.*

Teropiammon ($C_{60}H_{29}NO_6$), (Gerhardt's *nitride of opianyl* $N\left\{\begin{matrix} C_{20}H_9O_8 \\ C_{20}H_9O_8 \\ C_{20}H_9O_8 \end{matrix}\right.$ $+2\,HO$) is formed when narcotine is acted upon by dilute nitric acid. It crystallises from boiling alcohol in thin colourless needles.

Narcogenine ($C_{72}H_{38}N_2O_{20}$) was the name given by Blyth to the base in a platinum salt that he obtained after oxidising narcotine. It appears however to be merely a combination of the chloroplatinates of narcotine and cotarnine.

Alcohol-radical derivatives of narcotine. From the experiments of Wertheim it would seem that narcotine ($C_{46}H_{25}NO_{14}$) contains ethyl; he therefore represents its composition by the formula ($C_{42}H_{20}(C_4H_5)NO_{14}$), looks upon opianine ($C_{42}H_{21}NO_{14}$) as normal narcotine ($C_{42}H_{20}(H)NO_{14}$), and has succeeded in obtaining a methyl derivative ($C_{42}H_{20}(C_2H_3)NO_{14}$), and a propyl derivative ($C_{42}H_{20}(C_6H_7)NO_{14}$).

7. *Narceine* ($C_{46}H_{29}NO_{13}$). *Narceia.* So called from *νάρκη, stupor.* From the lead with which it is combined in the precipitate already mentioned, narceine is separated by sulphuretted hydrogen; the filtrate after evaporation to a syrupy consistence deposits silky crystals of narceine.

Narceine, purified by recrystallisation, occurs in colourless needles soluble in boiling water and in alcohol, but insoluble in ether. It is more fusible than morphine, or narcotine, and does not seem to be poisonous. Concentrated sulphuric acid colours it intensely red, changing to green on application of heat. Iodine gives it a deep blue colour. It forms crystalline salts with most of the acids, though in basic power it is somewhat feeble. The *hydrochlorate* contains ($C_{46}H_{29}NO_{18}$, HCl).

Porphyroxin (from *πορφύρεος, purple,* and *ὄξυς, acid*) is, according to Merck, another principle contained in opium. It is said to be a crystalline resin, and on its turning red when paper wetted with its ethereal solution is exposed to warm hydrochloric acid, is founded a test for the presence of opium in a compound mixture.

Pseudomorphine ($C_{27}H_{13}NO_{14}$?) is, according to Pelletier, occasionally met with in opium. It somewhat resembles morphine but does not form salts, is not affected by iodic acid, and apparently is not poisonous.

OPIUM, MEDICAL USES OF. [PAPAVER.]

OPIUM TRADE. The principal countries in which opium is prepared are India, Turkey, and Persia. The poppy is cultivated in Egypt and Arabia; in Italy, France, and other parts of Europe; but, with slight exceptions, rather for the sake of its capsule and the oil extracted from its seeds than for the inspissated juice. Indian opium is of three kinds, of which the chief are Patna, grown in the province of Bahar, and Benares, the former of which is most esteemed; the third kind, produced in the district of Malwa, is still less esteemed than that of Benares. The best Indian opium, however, is inferior to that of Turkey. For some time the quantity of opium produced and brought to the Eastern markets from all parts was not equal to the demand, and the Malwa and Turkish opium were introduced to supply the deficiency. At first there was a strong prejudice against the latter. The Turkey opium was introduced into the Indian Archipelago in 1815, and the merchants reluctantly consented to its constituting one-fourth of the supply for the year; but two years afterwards they expressly stipulated for one-half, and in the following year for three-fourths, although the price rose, while Indian opium was stationary. A strong preference has also been shown in China for the Turkish opium, which has been introduced by the Americans. Several thousand persons are engaged in the cultivation in Turkey; they are generally very poor, and the quantity annually brought to market by each cultivator does not exceed one or two baskets. The annual average produce of Turkey was estimated some years ago at about half a million pounds. The whole quantity of land under the poppy cultivation in India is said not to exceed 100,000 acres. Milburn ('Oriental Commerce,' p. 224) gives the following account of the opium monopoly, as maintained at a time when the East India Company was at the height of its power:—"The monopoly in the trade of opium, or the cultivation of the poppy, may be traced at least as far back as the commencement of the British influence in Bengal. The advantages resulting from it were for several years merely considered as a part of the emoluments of certain officers under the government. In the year 1773 the trade was taken out of their hands, and the profit assumed for the benefit of the Company. The provision of the article was for many years let out upon contract. The opium trade continued under the direction of the Board of Revenue till 1793, when it was transferred to the Board of Trade. On the expiration of the contracts, in 1797, the cultivation of opium was restricted to Bahar and Benares, and discontinued in Bengal: the mode of provision by agency was resorted to, and still continues in practice. In July, 1799, some regulations were published 'for the guidance of all persons concerned in the provision of opium on the part of government, and for preventing the illicit cultivation of the poppy and the illicit importation or traffic in the article of opium.' Under these regulations, which were further modified in 1807, the cultivation of the poppy, except on account of government, is expressly forbidden; but it is left entirely at the option of the cultivator to enter into engagements on account of government at a settled price, or to decline it altogether." Of recent events in the opium trade we shall speak presently.

Opium is often adulterated with the pulverised leaves and stalks of the poppy, which are mixed up into a mucilaginous mass with gum arabic or some similar substance. In Sumatra the opium prepared for smoking is frequently adulterated with pine-sugar, and crude opium with the fruit of the pisang, or plantain. An engrossing taste for opium pervades all classes in China, and has spread with astonishing rapidity. From the superior classes, who were the first to practise it, the habit of opium smoking has descended and become general. "Worthless subordinates in offices and nefarious traders," says Sir J. F. Davis, "first introduced the abuse; young persons of family, wealthy citizens, and merchants, adopted the custom; until at last it reached the common people. I have learned on inquiry, from scholars and official persons, that opium smokers exist in all the provinces, but the larger proportion of them are to be found in the government offices; and that it would be a fallacy to suppose that there are not smokers among all ranks of civil and military officers below the station of provincial governors and their deputies." Gutzlaff says of the Chinese sailors, that most of them are smokers of opium, and that when the weather is rough, and more than ordinary attention is required from them, they turn in and intoxicate themselves with this drug; and on shore they indulge in smoking it until all their wages are squandered. The tribes of the Indian Islands more frequently smoke opium than eat or chew it. They in fact chew tobacco and smoke opium, while the practice of the Turks and other people of Asia is directly the reverse. Raffles states that in Sumatra the opium prepared for smoking is used along the coast, whereas crude opium is chewed by the people of the interior. On the west coast of Celebes, the principal rajah and his family, and the various smaller rajahs amongst whom the country is divided, are the chief opium smokers: persons of inferior rank not being able to command the luxury. In some parts of India, opium is presented at visits and entertainments in the same familiar manner as a snuff-box in Europe. The prohibition of intoxicating liquors by the Mohammedan law has, it is believed, encouraged the habit of taking opium; and in consequence of the Turks of the present day being far less bigoted than formerly, the consumption of opium is said to have declined with the more frequent indulgence in wine and arrack. The habit is believed to be more prevalent at present in Persia than in Turkey, though it is not often carried to the same excess. In Europe opium is almost wholly employed as a medicine; it has been made in England from the native poppy, but the cultivation is not likely at any time to become worthy of attention on a large scale. The opium consumed in this country is chiefly from Turkey. Opium in small quantities is a permanent article of import from Italy and France; occasionally, but in still less quantities, it is imported from Russia, Germany, Holland, and Belgium; rarely from India. Within the last few years Egypt has exported opium to England, and the quantity has been yearly increasing. The supply received from each country is liable to great fluctuations, on account of the uncertainty of the crop.

It is in the relations between India and China that the opium trade is most important. Some authorities have stated that opium has always been prohibited in China; but this does not appear to have been the case. It was a legitimate branch of trade down to the close of the last century, prohibitory regulations having been first made in 1796. From this period the trade has always been contraband; and yet in little more than forty years the consumption of Indian opium in China rose from 1000 to 27,000 chests per annum. Opium constituted about one-half of the total value of British imports into Canton just before the opening of other Chinese ports to the British. Nothing but the extraordinary corruption of the Chinese authorities can account for this increase of a trade prohibited by the laws; but it is another proof of the difficulty of putting in force regulations which are at variance with the popular habits and taste. Macao was at first the centre of the Indian opium trade; but in 1802, in consequence of the conduct of the Portuguese towards the British merchants, the trade was removed to the island of Lintin. Here the opium was kept stored in armed ships, and delivered to the Chinese by written orders from Canton, on the sale being concluded and the money paid at that place. The price gradually fell, and the quantity imported gradually increased. Imperial edicts were frequently issued against opium dealers and smokers, but with little effect. There is reason to believe that the Chinese government was less alarmed about the introduction of opium, than at the drain of bullion which the opium trade occasions. Formerly the produce of China was paid for in silver, but opium has so successfully served the purpose as a medium of commercial exchange, that it has been less necessary to employ coin or bullion. The opium trade has thus been the means of draining China of the precious metals. The Chinese do not regard gold and silver as signs of wealth merely, but as wealth itself; and in many of their public documents relating to the opium trade the export of silver is also noticed; in some cases it is difficult to ascertain which is considered the paramount grievance. In 1836 an officer of the Chinese government proposed that opium should be rendered a legitimate article of commerce, and that the cultivation of the poppy should be permitted. Extraordinary as it may appear, the poppy is cultivated in at least six different provinces in China with the connivance of the local functionaries.

So important a source of revenue has the opium monopoly become to the Indian government, that war with China has been regarded as a less evil than a surrender of this privilege. The government is not the grower of the poppy, but controls the growers in an extraordinary way. None must be grown in Benares or Patna, except that of which the juice is sold to the government at a fixed price. No one is obliged to cultivate the plant, and therefore the government offers such a price as will just stimulate production; and this price is about 9*d.* per lb. for the juice, on an average of years. The government buys the whole produce, be it large or small, at this price. The poppy-fields are measured every year, and their boundaries fixed, in order to prevent collision among those to whom they are assigned. When the poppies are ripe, agents make a circuit of the district, and form by guess a probable estimate of the produce of each field; and the cultivators are made to sign an agreement to deliver the quantity thus estimated, and as much more as the field will yield. The rigour of the law is brought to bear upon those cultivators who depart from the agreement; they may cultivate the poppy or not as they please; but if they do, they become bound to the government in a most stringent way. The thickening of the juice by inspissating, the making up into balls, the classifying into qualities, and the packing in chests made of mango-wood (holding on an average about 140 lbs. each)—cost the government about 3*s.* per lb.; making, with the cost of the juice itself, something under 4*s.* per lb. on an average. Malwah is not a British possession, and the monopoly, therefore, cannot extend to that region; but the government, nevertheless, obtains a large revenue from Malwah opium, by imposing a frontier duty on all opium sent to Bombay or other ports for shipment; Malwah itself having no seaboard. Until 1834 the East India Company sent their own opium in their own ships for sale in China or elsewhere; but when the trading powers of the Company were abolished, a new system was organised. The opium from Patna and Benares is sold by auction. When packed in the chests, it is sent from the depôts at those two cities to Calcutta, where it is sold by auction to the highest bidders, who carry it to any market they please, but nearly all to China. The auction price has varied from 7*s.* to 21*s.* per lb., in different years; but the average is about 12*s.*, of which 8*s.* is clear profit. These auctions are held ten or twelve times in the year. The government not only pays the cultivator for his opium, but advances him money to assist in the culture: a system which throws him much into the power of the government agents. In the accounts of the Indian Revenue and Expenditure, annually laid before parliament, there are always items for—advances to opium-cultivators; purchase of poppy leaves; purchase of opium juice; packing and transit expenses; salaries of agents; and expenses of sale. So important to the exchequer of India is the 4,000,000*l.* or 5,000,000*l.* now annually derived from opium, that, though often objected to, it still remains untouched. The Marquis of Dalhousie, in 1856, published a minute, giving a sketch of the improvements which had been made in India during his Governor-Generalship from 1848 to that year; he spoke with pleasure of the opium-revenue, but said nothing about the *morale* of the trade. During the Indian mutinies of 1857-8, the opium-cultivators were much disturbed, and much of their property was destroyed; but the relations between the government and the cultivators continued as before. The transfer of the government from the East India Company to the Queen, in 1858, made very little if any change in these relations.

The above slight sketch of the opium-trade in reference to India may usefully be followed by a few words concerning the proceedings in China. The opium of India is chiefly bought by English and American merchants, who send most of it to China in low-hulled swift sailing vessels. Other portions go to Malaya, Sumatra, Borneo, Celebes, and other places in the East. The augmentation of price becomes enormous, either by a monopoly of the trade to native princes, or by the imposition of a high duty The opium clippers sent to China are mostly armed for self-defence, seeing that the trade is an illegal one in the eyes of the government, or is at least never openly recognised. There are always Chinese merchants willing to assist the English merchants in the traffic, and Chinese officials willing to be bribed into connivance; and hence there is very little difficulty in getting the opium landed on shore, in exchange for Sycee silver. There are no bills, bonds, or barter; pure solid silver, at so much per oz. is insisted on as the medium of purchase. It has been conjectured that the merchants obtain somewhat over a guinea a pound for the opium, in an average of years; but there are no means of determining this; whatever it may be, this price is enormously increased by the time the opium smokers and chewers obtain the drug in the interior of China. When, on the cessation of the East India Company's trading powers in 1834, a "Superintendent of Trade" was sent to China by the British Government, this superintendent was perpetually engaged in broils with the Chinese government concerning the opium trade; these broils led to the seizure and destruction of 20,000 chests of opium by the Chinese officials in 1839; and this seizure led to a state of hostilities which has had little intermission between 1839 and 1860. We refer to the articles CANTON, CHINA, HONGKONG, &c. in the GEOG. DIV. for an account of the various transactions in which Lin, Keshen, Kwan, and Ke-guy, figured on the part of the Chinese, and Davis, Elliott, Maitland, Brewer, Gough, Parker, and Pottinger on the side of the British.

OPOPO'NAX CHIRO'NIUM (Koch), a native of the south of Europe, and also of Asia Minor, a tall plant, often 8 feet high, from the base of the stem or summit of the root of which, when wounded, flows a yellow milky juice, which hardens on exposure to the sun and air. It occurs either in tears or in masses called placentæ. The tears are globose or angular, fatty to the touch, externally brownish-yellow, fragile, and, on being triturated, yield a yellow powder. The odour is strong, somewhat nauseous, resembling ammoniacum with a bitter balsamic taste. The specific gravity is 1·622.

Its constituents are resin, gum, and volatile oil. In its action on the human system it corresponds with the other gum-resins of the *Umbelliferæ*. [ASAFŒTIDA.] The *Ferula Hooshee*, a native of Beloochistan, produces a gum called hooshee, which, though not collected, resembles the opoponax of the European shops.

(Royle, *Flora of the Himalaya*, p. 231.)

OPPOSITION. [CONJUNCTION AND OPPOSITION.]

OPTIC AXIS. The line or lines in a doubly-refracting crystal in the direction of which no double refraction takes place, is termed the *optic axis* or *axes*. Iceland spar has but one optic axis, and this coincides with the axis of the rhombohedron. In uniaxal crystals the optic axis is identical with the geometrical. When the doubly-refractive forces neutralise each other, so that there is no double refraction in a particular direction, a line along that direction is sometimes termed the *resultant axis*. In uniaxal crystals the course of the extraordinarily refracted ray [REFRACTION; POLARIZATION] is constant for each crystal with relation to the optic axis; it is either refracted towards it, relatively to the ordinary ray, when the crystal is said to have a *positive* optic axis; or bent from it, when the crystal is said to have a *negative* axis.

OPTICS is that branch of physical science which explains the formation of images, as depending on the known laws by which the modifications of light are governed. [LIGHT.] These images are formed either by polished reflecting surfaces or by transparent refracting media. In the former case, the angles of incidence and reflection are equal; in the latter, the sines of the angles of incidence and refraction are in a constant ratio for one and the same medium. The position and magnitude of the image of an object is easily ascertained, when we have previously ascertained the position of the image of a point, in reference to the position of the point itself and of the reflecting or refracting instrument; in other words, when we have found the relation between the conjugate *foci*, so called because it universally holds in optics, that whichever focus be considered the object, the other will be the image. The *principal focus* of an instrument is that to or from which a pencil of parallel rays falling perpendicularly (or nearly so) on the instrument is made to converge or diverge after reflection or refraction. In a plane mirror the conjugate foci are similarly situated at opposite sides of the mirror [LIGHT]; consequently in this instance the instrument has no principal focus. Generally, the distance of the principal focus from the instrument is called the focal length of that instrument, whether a reflector or a refractor. Since conjugate foci are mutually such, it follows that rays proceeding from the principal focus will, after reflection or refraction, emerge in a *parallel* pencil. We shall now proceed to the relations existing between the conjugate foci of spherical reflectors, observing that the axis of the instrument is the right line containing the centre of the spherical surface and the conjugate foci. The rays under

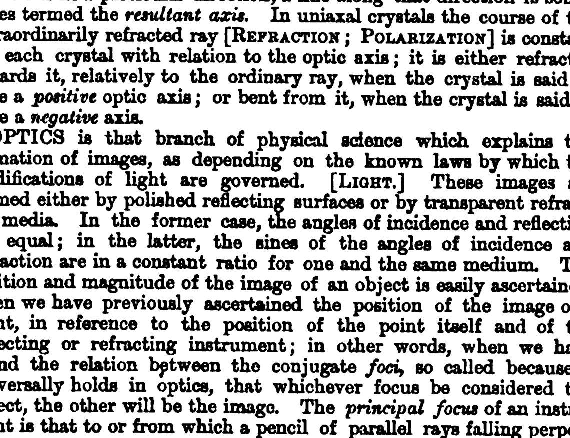


Fig. 1.

consideration are those which are directed nearly along the axis, and which therefore fall exceedingly nearly perpendicularly on the reflector.

Let DBE represent the section of a spherical reflector made by a plane passing through its axis, C its centre, A the focus of incident rays, AD an incident ray, ADC is the angle of incidence. Make the angle *a*DC = ADC, then *a*DC is the angle of reflection, and if the point of incidence D were infinitely near to the point B in the axis, then all the reflected rays of which the incidence was nearly perpendicular would converge to *a*, the latter would then be the focus conjugate to A, for if rays diverged from *a* they would after reflection evidently converge to A.

Now, if a straight line as CD bisect an angle of a triangle, as the angle AD*a*, it will divide the base into segments AC, C*a* proportional to the adjacent sides AD, D*a* ('Euc.,' book vi.), that is, AC : C*a* : : AD:D*a*; but when D is infinitely near to B, we may write AB and B*a* instead of AD and D*a*, in which case we should have AC : C*a* : : AB : B*a*. Let $AB=\Delta$, $aB=\Delta'$, and the radius $CB=r$; then $AC=\Delta-r$; $Ca=r-\Delta'$; whence $\Delta-r : r-\Delta' :: \Delta : \Delta'$, or $\Delta'(\Delta-r)=\Delta(r-\Delta')$; therefore $2\Delta\Delta'=r(\Delta+\Delta')$, which may be also written in the form $\frac{1}{\Delta}+\frac{1}{\Delta'}=\frac{2}{r}$. We should have precisely the same investigation if we had supposed rays as ED to fall on the convex side converging to a focus A; but being reflected in the direction D*e*, they would appear to diverge from the conjugate focus *a*: hence the above formula applies to two cases,—namely, when diverging rays fall on the concave surface, or converging rays on the convex surface, of a spherical reflector.

Example 1.—A candle is placed before a concave speculum at a distance of 3 feet from it: what will be the distance of its image from the same, the radius of the speculum being 2 feet?

Here we have given $\Delta=3$ feet, $r=2$ feet, and to find Δ' we substitute these numbers in the general formula $\frac{1}{\Delta}+\frac{1}{\Delta'}=\frac{2}{r}$, which thus becomes $\frac{1}{3}+\frac{1}{\Delta'}=\frac{2}{2}=1$; whence $\frac{1}{\Delta'}=\frac{2}{3}$, and therefore $\Delta'=\frac{3}{2}=1\frac{1}{2}$ foot; the image will consequently be 1 foot 6 inches in front of the speculum.

It being sometimes convenient to measure the distances of the foci from the centre instead of the surface of the speculum, it is easy to find a proper formula from the proportion we have established—namely, AC : C*a* : : AB : B*a*. Let $AC=\rho$, $Ca=\rho'$; then $AB=r+\rho$, $aB=r-\rho'$, whence $\rho : \rho' :: r+\rho : r-\rho'$, or $\rho(r-\rho')=\rho'(r+\rho)$, therefore $r(\rho-\rho')=2\rho\rho'$, consequently $\frac{1}{\rho'}-\frac{1}{\rho}=\frac{2}{r}$; thus, in the example given above, we find (since $\rho=1$ and $r=2$) $\frac{1}{\rho'}-1=1$, or $\frac{1}{\rho'}=2$; therefore $\rho'=\frac{1}{2}$, which is agreeable with the former result.

When the incident rays proceed from a point exceedingly distant (as the sun for instance), then Δ being very great $\frac{1}{\Delta}$ will be exceedingly small and may be rejected, in which case we have $\frac{1}{\Delta'}=\frac{2}{r}$ or $\Delta'=\frac{r}{2}$, that is, parallel incident rays are made after reflection to converge to F, the middle point of the radius CB. Hence the focal length of a spherical speculum is one-half that of its radius.

In examining the formula for the positions of the conjugate foci, namely, $\frac{1}{\Delta}+\frac{1}{\Delta'}=\frac{2}{r}$, we find that when $\Delta=r$ we also must have $\Delta'=r$; hence when the focus A is at C the centre, the conjugate focus *a* will be at the same point. If A move to the left of C (in *fig.* 1), Δ being then greater than r, $\frac{1}{\Delta}$ is less than $\frac{1}{r}$, and therefore $\frac{1}{\Delta'}$ must be greater than $\frac{1}{r}$ or Δ' is less than r, and as Δ increases to greater magnitudes, Δ' accordingly diminishes, until Δ becomes infinite, when Δ', as we have seen, becomes $\frac{r}{2}$: hence, whilst A moves on the left indefinitely from C, the other focus moves on the right from C as far as the principal focus F.

With respect to the images formed by concave specula, let AG represent a small object at A, the line AG being perpendicular to AC, join GC, then GCE will be the axis of the speculum when G is considered the focus of incident rays, and its conjugate focus *g* can be found by the preceding formula: hence *ag* will be the image of AG, its position is evidently inverted, and it is easy to see that the line *ag* is very nearly perpendicular to CB; and by similar triangles, the linear dimensions of the image *ag* are to those of the object AG as C*g* : CG, or as $\rho' : \rho$. Now the formula $\frac{1}{\rho'}-\frac{1}{\rho}=\frac{2}{r}$ gives $\frac{\rho'}{\rho}=\frac{r}{2\rho+r}$; hence the image (in respect to linear dimensions) is less than the object in the ratio of $r : 2\rho+r$ (or since $\rho=\Delta-r$) as $r : 2\Delta-r$; on the contrary, if the object be placed between the centre and principal focus, as at *ag*, then AG would become the image; for $AG : ag :: \rho : \rho'$; but $\frac{\rho}{\rho'}=\frac{r}{r-2\rho'}=\frac{r}{2\Delta'-r}$; therefore $AG : a'g :: r : 2\Delta'-r$; which shows that the image is then greater than the object, or magnified. From the principles of geometry it follows that the surfaces of the image and object are as the squares of the linear dimensions, and the apparent volume, or bulk, as their cubes.

Example 2.—An object is placed at a distance of 12 feet in the axis of a concave speculum of two feet radius: to find how much it will appear diminished in its image, with respect to its linear, superficial, and solid dimensions.

Here $r=2$, $\Delta=12$, $2\Delta-r=22$; therefore

for linear dimensions Image : Object : : 2 : 22,

that is : : 1 : 11;

for superficial do. the ratio is as 1 : 121, and for apparent bulk it is as 1 : 1331.

Heat being capable of reflection, like light, the rays of the sun may be collected by a concave speculum in its principal focus (or burning-point) F.

Example 3.—To find how much an object will be magnified by the same speculum, when placed 1 foot 6 inches in front of it.

Here $\Delta'=1\frac{1}{2}$, $r=2$, $2\Delta'-r=1$; therefore in linear dimensions the ratio is as 2 : 1;

in superficial as 4 : 1;
and in cubical as 8 : 1.

Let us next consider the relation between the conjugate foci when diverging rays fall on a convex spherical speculum, which will also be the relation when converging rays fall on a concave speculum as will be evident by inspection of the figure (*fig.* 2). Employing the same letters with the diagram as before, C will be the centre, A the focus of incident rays, *a* of reflected rays, &c.

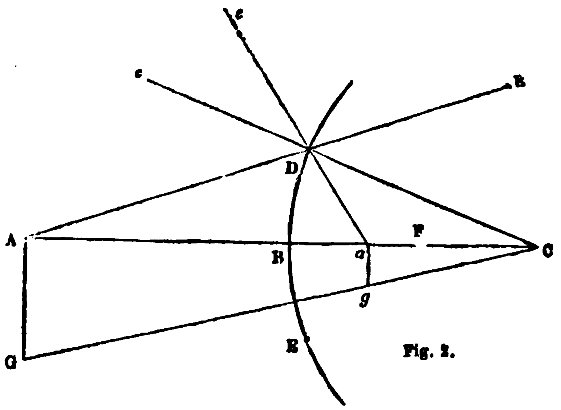


Fig. 2.

Let AD be an incident ray near the axis AC, join CD and produce to *c*; make the angle of reflection *c*D*e* equal to the angle of incidence AD*c*, and produce the reflected ray D*e* to meet the axis in *a*; then when D is infinitely near B, *a* is the focus conjugate to A. The same figure would equally apply if we had supposed rays ED converging to A to fall on the concave surface, for since the angles AD*c*, *c*D*e*, *a*DC, CDE are all equal, D*a* would then be the actual reflected ray and therefore *a* would be still the focus conjugate to A. Now since the external angle *a*DE of the triangle AD*a* is bisected by the straight line DC, it follows (Simson's 'Euc.,' book 6) that AC : C*a* : : AD : D*a* (and D being supposed infinitely near to B in order that the rays may be incident nearly perpendicularly) : : AB : B*a*. Let $AB=\Delta$, $aB=\Delta'$, $CB=r$, $CA=\rho$, $Ca=\rho'$, then we have

$$\rho : \rho' :: \Delta : \Delta', \text{ or } r+\Delta : r-\Delta :: \Delta : \Delta', \text{ hence}$$
$$\Delta'(r+\Delta)=\Delta(r-\Delta'),$$

therefore $2\Delta\Delta'=r(\Delta-\Delta')$ whence $\frac{1}{\Delta'}-\frac{1}{\Delta}=\frac{2}{r}$. Again the same proportion $\rho : \rho' :: \Delta : \Delta'$ may be written $\rho : \rho' :: \rho-r : r-\rho'$; hence $\rho(r-\rho')=\rho'(\rho-r)$ therefore $r(\rho+\rho')=2\rho\rho'$ whence $\frac{1}{\rho}+\frac{1}{\rho'}=\frac{2}{r}$.

If we suppose $\rho=r$, we find $\rho'=r$, which shows that the foci are together at B, and as ρ increases, ρ' diminishes, until ρ becomes infinite, when $\rho'=\frac{r}{2}$, showing that *a* will then reach the principal focus F. Hence, in general, the principal foci move in contrary directions, and meet both at the centre and circumference. In the formula just given one of the conjugate foci lies between the principal focus and the surface of the speculum; while in the first set, one lay between that point (F) and the centre. A single formula, however, as the reader may verify, will include all cases, whether of concave or convex specula, or divergent or convergent pencils, provided we admit the use of negative quantities, and interpret the negative sign to mean that the distance affected by it must be measured in a direction contrary to that in the figure on which the formula was framed.

With respect to images, if AG be the object and *g* the focus conjugate to G, then *ag* will be the image of AG; and conversely, if *ag* be the object, A G will be the image, and their proportion may be easily calculated, for A G : $a\,g$ :: C A : C a, that is, as $\rho : \rho'$, or as $\Delta : \Delta'$, which we have seen is the same ratio.

Example 4.—In the concave speculum of two-foot radius, an object is placed within 6 inches of its interior surface: how far will the image appear at the back of the speculum, and how much will it seem enlarged?

Here $r=2$, in feet, $\Delta'=\frac{1}{2}$, and since $\frac{1}{\Delta'}-\frac{1}{\Delta}=\frac{2}{r}$ we have $2-\frac{1}{\Delta}=1$, therefore $\Delta=1$, or the image will appear a foot behind the convex side and will be enlarged in linear dimensions as Δ to Δ', that is, as 2 to 1; in surface 4 : 1; in volume 8 to 1.

Example 5.—An object is placed 10 feet distance from a convex speculum of 3 feet radius; find the position and magnitude of its image.

Here $r=3$, $\Delta=10$, therefore $\frac{1}{\Delta'}-\frac{1}{10}=\frac{2}{3}$, whence $\frac{1}{\Delta'}=\frac{23}{30}$, therefore $\Delta'=1\frac{7}{23}$ feet, or 1 foot 3 inches, 8 parts nearly, at which distance in the concavity of the speculum the image will seem to be, and (in linear dimensions) Object : Image :: $\Delta : \Delta'$ :: $10 : \frac{30}{23}$, that is as 23 : 3; the surfaces as 529 : 9, &c. Thus the reader with only a moderate knowledge of simple equations will be able to solve all questions relative to the images of objects formed by spherical specula, concave or convex. The images in the last two examples are erect. Generally the image will be erect or inverted according as one of the conjugate foci is between the principal focus and surface, or between that point and the centre; and this will include all cases, for it is easily seen that in every case one of the foci is in some part of the radius between the centre and surface.

In the preceding calculations, we have confined ourselves to such rays as fall nearly perpendicularly on the reflecting surfaces. The rays which are at a considerable distance from the axis of a spherical speculum are not reflected accurately to the same point as those incident near the axis; hence arises a diffusion of the reflected rays arising from the sphericity of the speculum and denominated the *spherical aberration;* and when measured *along* the axis, it is called the *longitudinal aberration;* but when perpendicular to it, through the focus, the *lateral aberration.* It will be sufficient in this article to calculate the amount of these aberrations in the most usual case when the incident rays are parallel, as those which proceed from the heavenly bodies.

Let S D represent a ray falling parallel to the axis C B; B D being the intermediate arc of the section of the speculum, D a the reflected ray; if this figure revolve round C B, it is evident that all rays incident on the annulus through which D moves will likewise be reflected to a, which is therefore strictly the focus of that annulus. Now F, the middle point of C B, is the point to which rays falling near the axis are reflected; hence a F is the longitudinal and F b the lateral aberration corresponding to the above annulus. To calculate the amount of these we may observe that the angle S D C (of incidence) is equal to C D a (of reflection), and also to D C a (by the theory of parallels); and since the angles a D C, a C D, are thus equal, therefore C a = a D. Let D T be a tangent at D, then a D T and a T D, being respectively the complements of a D C and a C D, are also equal, whence a T = a D, but also C a = a D, therefore a is the middle point of C T; and since F is the middle of C B, it follows that a F is the half of B T; thus the longitudinal aberration is known; and since the angle F $a\,b$ is the double of D C B, the lateral aberration is from thence known. Let the angle D C B = θ, and radius C B = r, then C T = r sec. θ and B T = r (sec. $\theta-1$), hence we obtain the exact values of the two aberrations, namely, the longitudinal $=\frac{r}{2}(\text{sec. }\theta-1)$, and the lateral $\text{F}b=\frac{r\,\text{tan. }2\,\theta}{2}(\text{sec. }\theta-1)$. Hence in order that the aberrations may be inconsiderable, we ought to have the extreme magnitude of θ, namely, the angle B C d (in *fig.* 3), also small. On this supposition formulæ sufficiently approximate may be deduced from the above and better adapted for practice. For sec. θ put $1+\frac{\theta}{2}$, and for tan. $2\,\theta$ put $2\,\theta$, which are respectively the approximate values; thence we get, longitudinal aberration $=\frac{r.\theta^2}{4}=\frac{\text{B D}^2}{4\,\text{B C}}$, and lateral aberration $=\frac{r.\theta^3}{2}=\frac{\text{B D}^3}{2\,\text{B C}^2}$, both of which are evidently very small, particularly the latter. The least circle of aberration is the smallest that would be formed on a card placed perpendicular to the axis near the focus F to receive the reflected rays; now if the intersection g of a reflected ray D g with the final one $d\,g$ be taken the most remote possible from the axis C B, it is evident that all the other reflected rays will pass between g and the axis, and hence the perpendicular distance from g to the axis is the radius of the circle of least aberration or diffusion. The question is thus reduced to one of maxima and minima, and may be easily solved in the usual manner by means of the Differential Calculus.

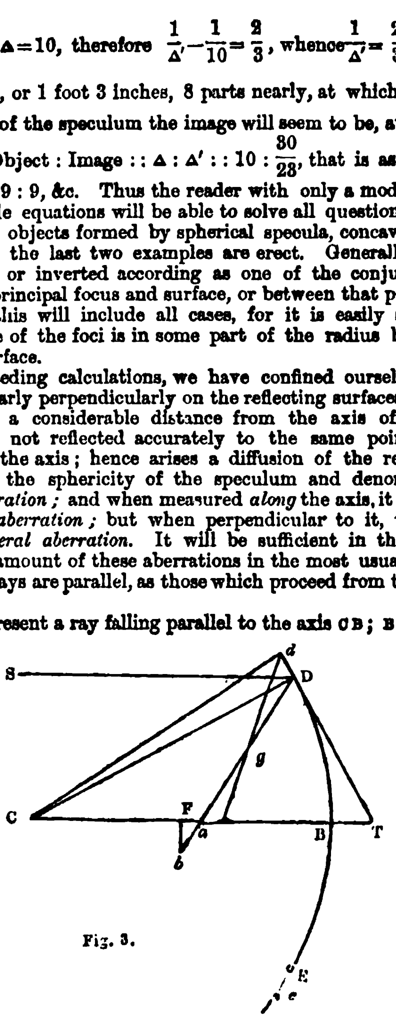


Fig. 3.

We have hitherto considered only such rays as fall nearly perpendicularly on the reflecting surface; but since rays fall at all incidences from a luminous point, each pencil of rays, at whatever incidence, when in a plane passing through the centre of the spherical reflecting surface, after reflection converges to or diverges from some point in that plane (unless reflected parallel); a line of light containing all such points in that plane forms a *caustic* line, and in all possible planes constitutes a caustic surface. Caustics formed by reflection have been distinguished from those produced by refraction by giving the name of diacaustics to the latter and catacaustics to the former, in the same manner in which that part of optics connected with refraction has been denominated dioptrics, and that with reflection catoptrics. In both cases the caustic line is the curve which each reflected or refracted ray *touches:* hence the equation to the caustic curve, whether produced by parallel, diverging, or converging rays, is easily obtained by taking the equation to one of the reflected or refracted rays, and then applying the differential calculus to find the curve touched by all such straight lines; namely, differentiate the equation to the reflected or refracted ray relatively to the constant in its equation, and then eliminate the constant between the two equations, which will then produce the equation to the caustic. In the general case of a system of rays no longer symmetrical about an axis we still have caustic surfaces, but the problem is then one of greater complexity. If the sun or a candle shine on a vessel containing liquid, and polished in the interior (such as a china cup of tea), a caustic line of light will be observable on the surface of the liquid, which line is a horizontal section of the caustic surface by that of the liquid.

We now come to the consideration of refracting transparent media; and if we suppose the constant ratio of the sine of incidence to that of refraction to be as $m : 1$, then m is called the index of refraction for the particular medium employed, the incident light being supposed to pass from vacuum. But if the light pass from the medium into vacuum, then the ratio of the sine of incidence to that of refraction will be as $1 : m$, and $\frac{1}{m}$ will be the refractive index; m is evidently greater than unity, since the ray after entering the medium is turned towards the perpendicular, and $\frac{1}{m}$ is less than unity, because after the ray emerges from the medium into vacuum, it is turned from the perpendicular. If m be the index of refraction from vacuum into one medium which we may call A, and m' that from vacuum into a different medium B, then $\frac{m'}{m}$ is the index when the light passes from the medium A to B. [LIGHT.] A table of refractive indices is given in OPTICS, PRACTICAL.

Diverging rays fall from vacuum on the *plane* surface of a uniform and transparent medium: it is required to find the relation between the conjugate foci.

Let A be the focus of incident rays, D B E the surface of the medium, A B a perpendicular on D E, A G an incident ray near this perpendicular, G C (A G produced) the course of the ray if unrefracted, G c its actual course nearer to the perpendicular than G C, then c G to an eye placed in the medium will appear to proceed from the point a, the conjugate focus; the question is to determine the relative situations of a and A.

Let A B = Δ, a B = Δ', and m be the index of refraction; then B A G, the complement of A G B, is equal to the angle of incidence, and B a G to that of refraction. Let these angles be respectively denoted by I and R, and B G = k; then $k=\Delta$ tan. I, and also to Δ' tan. R, therefore $\frac{\Delta'}{\Delta}=\frac{\text{tan. I}}{\text{tan. R}}=\frac{\text{sin. I}}{\text{sin. R}}\cdot\frac{\text{cos. R}}{\text{cos. I}}=m.\frac{\text{cos. R}}{\text{cos. I}}$; but when G is very near B, the angles I and R are exceedingly small, and their cosines may be taken as units, in which case $\frac{\Delta'}{\Delta}=m$, therefore $\Delta'=m\Delta$; and since m is greater than unity, Δ' is greater than Δ in the ratio of $m:1$. Conversely, if a ray from a medium bounded by a plane surface pass into vacuum,

$\frac{1}{m}$ is then the index of refraction, and we should have $\Delta' = \frac{1}{m} . \Delta$, in which case Δ' is less than Δ. This explains why the bottom of a clear river seems nearer to the surface than it really is by about one-fourth of its true depth.

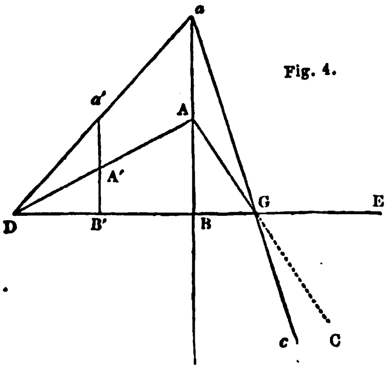


Fig. 4.

The image of a straight line in vacuo seen from such a medium will be another straight line; for let A A' be such a line, produce it to D, and join D a, then since a'B' : A'B' : a B : A B : : m : 1; therefore a' is the focus conjugate to A', and consequently $a\,a'$ is the image of A A'. It must however be observed that A A' must be of small dimensions, in order that the rays reaching the observer's eye may be considered as nearly perpendicular to D E, otherwise the above proportion would require to be modified, and the image would be curved. In the above case the image $a\,a'$ is more remote from the surface D E than the object; but the contrary happens when the object is in the medium, when the image will be nearer the surface than the object is. Hence many familiar optical phenomena may be understood. Thus, when a straight stick is partly immersed in water, the image of the immersed part being raised nearer to the surface than the true object, will cause the stick to appear bent or broken, as well as shorter than it really is; but when immersed perpendicularly to the surface, the stick appears to be only contracted about one-fourth of the part immersed, for the image and object are then in one straight line.

As refracting media bounded by a single curved surface rarely if ever can occur in practice, we shall proceed to consider lenses, particularly the double convex lens, as known most generally. For their various species and for further details see LENS.

Let D B E B' represent a plane section of a double convex lens, that plane including the centres C C' of the bounding surfaces D B E and D B'E; let A (in the *axis* C C') be the focus of incident, and a of the emergent rays. Let m be the index of refraction for incident, and therefore $\frac{1}{m}$ for emergent rays; and let A G K a represent the track of a ray near the axis; let C B $= r$; C' B' $= r'$, A B $= \Delta$, a B' $= \Delta$, and the thickness B B' $= t$, we have to determine the relation existing between these quantities. First we have sin A G $c = m$ sin K G c, let G A C $= \theta$, G C A $= \alpha$, and the inclination of K G to the axis be ϕ; while δ is the distance of the point at which G K cuts the axis from B; then the above equation is the same as $\sin(\theta+\alpha) = m \sin(\phi+\alpha)$, from which by trigonometry we deduce $\frac{\sin\theta - m\sin\phi}{\sin\alpha} = \frac{m\cos\phi - \cos\theta}{\cos\alpha}$. Now $\frac{\sin\theta}{\sin\alpha} = \frac{\mathrm{C\,G}}{\mathrm{A\,G}}$, of which the ultimate value, when G is at B, is $\frac{\mathrm{C\,B}}{\mathrm{A\,B}} = \frac{r}{\Delta}$, for the same reason the ultimate value of $\frac{\sin\phi}{\sin\alpha}$ is $\frac{r}{\delta}$, and the ultimate values of $\cos\theta$, $\cos\phi$ and $\cos\alpha$, are each unity; therefore we get $\frac{r}{\Delta} - \frac{mr}{\delta} = m-1$, or $\frac{1}{\Delta} - \frac{m}{\delta} = \frac{m-1}{r}$; hence δ, which determines the focus of the first set of refracted rays, is known; and therefore also $\delta + t$, which is its distance from the second surface. Now, since the ray would traverse the same course if we supposed it to commence at a, and proceed through a K G to A, it follows in the same way that $\frac{1}{\Delta'} + \frac{m}{\delta+t} = \frac{m-1}{r'}$, from whence Δ' is known.

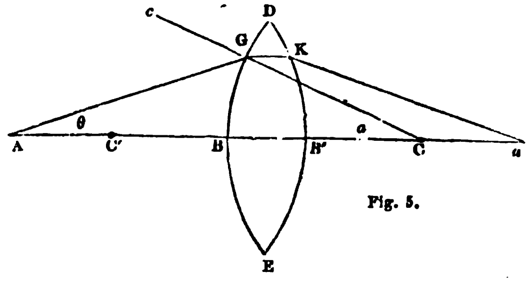


Fig. 5.

If we neglect t as being small, we may eliminate $\frac{m}{\delta}$, and thence obtain $\frac{1}{\Delta'} + \frac{1}{\Delta} = (m-1)\left(\frac{1}{r'} + \frac{1}{r}\right)$; the spherical aberrations may be found by a similar process to that we have employed for reflection, and the inverse or erect positions of the images ascertained by the like method.

When we have one side plane, we have only to suppose r infinite, and when concave to suppose r negative, and thus one general formula, by proper attention to the signs, may be made to apply to all forms of lenses.

There is a cause of aberrration for refracted light, which does not exist for reflected rays, and it is of more consequence in deforming and colouring images than all the effects of spherical aberration. The chromatic dispersion [DISPERSION] arises from the fact that all the coloured rays which compose solar or other light have different refractive indices for one and the same refracting medium; hence the prismatic spectrum, which only consists of successive circular images of the sun, of the different colours of the rays, overlapping each other. This aberration has, by the successive labours of Dollond, Fraunhofer, and others, been successfully combated. [OPTICS, PRACTICAL.]

The possibility of correcting the aberration arising from the unequal refrangibility of rays of light in the refracting telescope, by means of a compound object-glass, permits the employment of object-glasses of a much larger diameter, in comparison with their focal length, than could otherwise have been tolerated. Now for a lens of given focal length, the spherical aberration increases rapidly with the aperture. It becomes therefore of importance to correct as far as possible this aberration by giving appropriate forms to the surfaces, or by combining together two or more lenses.

Writers on optics show that a curve-line by whose revolution about an axis there shall be described a surface which, being that of a refracting medium, will cause all rays incident upon it, when they diverge from or converge to one point, to be refracted so as to converge to or diverge from one point is, in its most general form, of the fourth order: but when the radiant point is at an infinite distance from the refracting surface, as when it is at a celestial body, the form of the surface, supposing the density of the refracting medium to be greater than that of the medium which surrounds it and in which are the incident rays, is proved to be that of a spheroid: and rays falling on its convexity, parallel to the major axis of the spheroid, would, within the medium, converge accurately to the focus most remote from the place of incidence. If the refracting medium were less dense than that in which are the incident rays, the surface would be that of an hyperboloid. The semi-transverse axis both of the spheroid and hyperboloid must be, to the excentricity, as the sign of the angle of incidence is to the sign of the angle of refraction: in the former case the refraction is from the surrounding medium into the spheroid; and in the latter, from the concave surface of the hyperboloid into the surrounding medium. It follows therefore that if a meniscus lens denser than the surrounding medium have its anterior surface spheroidal, and its posterior surface that of a sphere whose centre is at the further focus of the spheroid; since the rays will then suffer no refraction in passing through the posterior surface, it will be aplanatic. Also if the anterior surface of a medium be plane, so that the parallel rays incident perpendicularly on it may suffer no refraction in entering, and the other surface be part of a hyperboloid, the medium between the surface being denser than that which surrounds it, the plane lens thus formed will be aplanatic; the refracted rays converging to the opposite focus of the hyperbola.

The form of the expression for aberration, when parallel rays are incident on a lens of moderate aperture having spherical surfaces, is such that the aberration cannot be made to vanish with any real values of the radii of those surfaces unless the index of refraction in the medium be equal to or less than 0·25. But there is in nature no medium which has such a refractive index, therefore, failing in making spherical lenses strictly aplanatic, and it having been found impossible, hitherto, to form them with surfaces produced by the revolutions of conic sections, mathematicians have investigated expressions for the form under which, with a given refractive index, the aberration of the focus shall be a minimum; see the article "Light" in the 'Encyclopædia Metropolitana' (art. 305), where the ratio between the radii of the surfaces, in this state, is given. From that ratio it is shown that, when the index of refraction is 1·5 the lens should be of the double convex form, having the radius of the posterior surface six times as long as that of the anterior surface, or that which is nearest to the radiant point.

But although the spherical aberration for a pencil of parallel rays cannot be made to vanish in a single lens bounded by spherical surfaces, the compound lens employed in an achromatic object glass, designed in the first instance to correct the chromatic aberration, has the further advantage of enabling us to render insensible the spherical aberration. Such a lens presents us with four spherical surfaces, the three independent ratios between the radii of which enable us to satisfy three conditions, while the scale of the system is determined by the focal length of the combination. The most important condition to satisfy is, that the chromatic aberration shall be corrected; and if we further assume that the spherical aberration (or rather its leading term) shall vanish, we shall still have one relation between the four radii remaining disposable, whereby some further advantage may be secured, provided it be not incompatible with those already assumed, which will be known by its leading, when the condition of it is expressed analytically, to an equation having only impossible roots. Clairaut introduced the condition that the adjacent surfaces should have the same radii, one surface being convex and the other concave, so that the lenses would be everywhere in contact, and might be cemented together. Instead of this, Sir J. Herschel proposes to introduce the condition that the lens shall be aplanatic for pencils, not only of parallel, but also of slightly divergent rays. In the treatise on light above quoted (arts. 468-473), he has pointed out certain advantages of this method, and has computed with different dispersive ratios a table of the radii of the lenses for the compound object-glass of a telescope constructed according to this system as nearly aplanatic as possible, the compound focal length being 10·000; and, by the proportions indicated, the radii for object-glasses of any other compound focal length may be found. (On the subject of aplanatic lenses for microscopes, see MICROSCOPE.)

It may be well here to make a few remarks about the eye, regarded merely as an optical instrument, its general structure and functions being very fully described under the article EYE, in the NAT. HIST. DIV. In this point of view its general office resembles that of a telescope in having to form images of distant, or moderately distant objects at its focus, which in order that the vision may be distinct must coincide with the retina. It differs, however, from a telescope, in having the whole space between the place of the first refraction and that of the focus filled with dense matter, in not having the refraction at the several surfaces centrical, and in having a much larger aperture, in comparison with the focal length, than could be tolerated in the best telescope.

On account of the magnitude of this aperture, the effect of spherical aberration might be seriously inconvenient if the media of which the eye is composed were severally homogeneous and bounded by spherical surfaces. The defects of spherical aberration, it should be remembered, increase very rapidly with the aperture of a telescope, more rapidly than those of chromatic aberration. It is at the surface of the cornea that the main refraction takes place, and the protuberant form of this part of the eye seems calculated to diminish the aberration; for we have seen that a prolate spheroid of suitable excentricity refracts accurately to a point a pencil of rays incident parallel to its axis. The increasing density of the crystalline lens in passing from its exterior to its centre has a similar tendency, since an ordinary glass lens fails to refract a pencil of parallel rays accurately to a point in consequence of the over refraction of the marginal rays compared with those incident towards the middle.

No compensation for the chromatic aberration of direct pencils seems to exist, or to be required. If a pure spectrum be thrown on a page of small print, and the page be viewed by a person of ordinary sight at the ordinary distance of reading, the print will be seen very distinctly about the bright part of the spectrum, but somewhat indistinctly from long-sightedness in the red, and very indistinctly from short-sightedness in the violet. Again, if the sun or a candle be viewed through several pieces of cobalt blue glass superposed, a combination which transmits only the extreme red, and the blue and violet of the spectrum, the red image and the blue image, though superposed, will not be seen in focus together. But in ordinary vision, where all the colours of the spectrum are viewed together, the confusion arising from the imperfect focusing of the fainter extremities of the spectrum is insensible.

If the eye were perfectly invariable in form, the images of objects at different distances could not all be formed *on* the retina, and therefore, such objects could not all be seen distinctly. The eye, however, possesses a power of adaptation, answering to the focusing of a telescope, which accompanies involuntarily the voluntary act of making the axes of the two eyes converge towards a nearer or more distant object by *looking at* the object.

If the cornea be too protuberant, the rays will be brought to a focus before reaching the retina (unless they come from an object close at hand), and the vision will be indistinct. A person thus affected is said to be *short-sighted*. If the cornea be too flat, the rays will reach the retina before they come to a focus (unless they come from a very distant object, and perhaps not even then), and the vision will again be indistinct, such a person being said to be *long-sighted*. These defects, as is well known, may be corrected by the use of spectacles, respectively concave and convex, and of suitable power. But there is another defect, consisting in the length of sight being different in different planes, which is far from uncommon, which cannot be corrected by ordinary lenses, though it may by a properly chosen lens having one or both surfaces cylindrical. [LENS.]

OPTICS, PRACTICAL, is that part of science which applies the physical properties of LIGHT and the mathematical laws of OPTICS to the construction of useful optical instruments. By the former we determine the constants necessary to render the formulæ of the latter convertible into numbers. The refractive and dispersive indices peculiar to transparent media are constants of this nature, and the instruments adapted to the easy vision of near or distant objects, to great or small objects, and to other optical purposes, are, according to the plan of this work, described under their proper heads. [CAMERA LUCIDA; HELIOSTAT; MICROSCOPE; TELESCOPE; &c.]

The refractive indices of transparent and semi-transparent media have been a subject of research to many experimenters, and were considerably advanced by Newton. (Newton's 'Optics.') The additional properties of light discovered since his time have enabled philosophers to calculate to a far greater degree of accuracy the indices both of refraction and dispersion than was then practicable.

The theory of achromatism, or the method of correcting the aberrations of the rays of light, has been pursued by Euler, D'Alembert, Herschel (Sir J.), and many others; but the earliest successful construction was made by Mr. Hall, in 1733. The same was effected in 1757 by Dollond, whose labours, together with that of his son, gave a great impulse towards the complete accomplishment of an object of which Newton seems almost to have despaired. In the same career of late years we must distinguish Fraunhofer, of Benediktbeuern, in Bavaria, who obtained at an early age from the French Academy the prize for the actual construction of achromatic glasses. Not only were the necessary manual operations conducted by himself with patience and the minutest attention to all the practical details of the quality of his glasses and the accuracy of grinding and polishing, but he had also the merit and advantage of observing the dark lines which cross the prismatic spectrum, and which are of the greatest utility in determining the indices above alluded to. From the nature of the composition of the glasses, some of his finest telescopes have of late become considerably tarnished, particularly those in exposed situations. This could not have been easily foreseen, and many of his telescopes remain still in good condition.

The first account of Fraunhofer's remarkable optical discoveries is given in a paper which he published in the 'Memoirs of the Academy of Bavaria' for 1814-15. By means of a theodolite furnished with a telescope, he measured the distances of the principal lines; and by applying a photometer to the different coloured rays, he drew a curve, the ordinates of which express the illuminating powers of the several rays. To these researches he soon afterwards added some beautiful experiments on the diffraction of light, an account of which he published at Munich, and they also appeared in an abridged form in the 'Bibliothèque Universelle,' January, 1822. It is believed that his close application to those and similar researches accelerated his death, which followed soon after.

The accurate determination of the refractive and dispersive indices has also been pursued with great success in this country, and simultaneously by some of the following distinguished men:—Dr. Thomas Young, Dr. Brewster, Dr. Wollaston, Sir. J. Herschel, Prof. Faraday, Prof. Powell, &c.; and in France, by Biot, Dulong, &c.; some of the results of whose experiments, in a very compressed form, are given in the two following tables:—

REFRACTIVE INDICES.

Hydrogen	1·00014	Glass—English plate	1·500
Oxygen	1·00027	Dutch	1·514
Air (atmospheric)	1·00029	Fraunhofer's crown (No. 13) ray E	1·533
Nitrogen	1·0003	Rock crystal	1·568 to 1·575
Aqueous humour of eye	1·337	Amber	1·547
Vitreous	1·336	Ruby red glass	1·601
Salt-water	1·343	Sulphur	1·958
Albumen	1·360	Glass of antimony	2·000
Crystalline lens of eye	1·378	Diamond (S. G.=3·4)	2·439
Oil of almonds	1·470		
Oil of turpentine	1·475		
Camphor	1·500		

DISPERSIVE POWERS.

Chrom. lead	0·400	Oil of turpentine	0·043
Oil of cassia	0·139	Amber	0·041
Green glass	0·061	Gum Arabic	0·036
Flint glass	0·052	Oil of cloves	0·062
		Sulphate of lead	0·060

OPTO'METER (from ὄπτομαι, to see, and μέτρον, a measure) is an instrument for ascertaining with precision the refractive powers of lenses, and the distances at which minute objects may be distinctly seen. The idea originated with Scheiner; but such an instrument was constructed by Dr. Porterfield, and was improved by Dr. Thomas Young. It consisted of a slip of ivory, unpolished, or of wood covered with white paper, about eight inches long and half an inch broad, on which, in the direction of its length, was drawn a narrow and well-defined black line. At one extremity of the slip was fixed a plate of ivory, or a piece of card, nearly perpendicular to its length, and this was perforated either with a single aperture or with two apertures at distances from one another varying from $\frac{1}{40}$th to $\frac{1}{10}$th of an inch, but not exceeding the diameter of the pupil of the eye. On applying the eye to a single aperture, and looking in the direction of the line, drawn on the instrument, the line appears to have a certain breadth, and to be ill defined, at the nearest extremity: the breadth gradually diminishes at points successively more remote till it becomes a minimum, when the line becomes distinct; beyond that point the line gradually increases in breadth, becoming again ill defined. On applying the eye to a double aperture, the line appears to be double, the parts seeming to cross one another at a very acute angle, and the intersection is at the place where a single line would have had the minimum breadth:

beyond this intersection the two lines appear to diverge from one another, and to become indistinct. The point of intersection is that at which a minute object being placed, its image would be distinctly seen by the eye at the aperture, and its distance from the eye may be immediately found by means of a scale of inches on the instrument, a sliding index being, at the time of making the observation, moved to the point of intersection.

This distance affords, evidently, a measure of the refractive power of the observer's eye; since rays of light diverging from a small object at that distance are, by the lenses of the organ, made to converge accurately to a point on the retina, so as to form there a single and well defined image. If the object were either brought nearer to or removed farther from the eye, the rays, after passing through the two apertures, would form two images, both of which would appear to be less perfectly defined than the single image.

It being assumed that a person whose sight is perfect sees a small object distinctly at the distance of 8 inches from the eye, Dr. Young obtained by computation a series of numbers which he placed on the scale of the optometer, at such distances from the plate containing the apertures, that a spectator having a *presbyopic* eye (or one which, like those of most persons who are advanced in life, has distinct vision of small objects only when they are at greater distances than 8 inches) on looking through the slits and observing the place where the two images of the line cross each other, might ascertain at once, by the number at the place, the focal length of a convex lens which would enable him to see distinctly at 8 inches. He also computed a series of numbers which he placed on the scale in such situations that a person having a *myopic* eye, or one which has distinct vision of objects at less than that distance from it, on observing the place at which the lines appeared to intersect one another, might ascertain the virtual focus of a concave lens which would enable him to see distinctly at 8 inches. The optometer thus became a means of enabling persons to make choice of the proper lenses for spectacles which would correct the imperfections of their natural vision.

But the scale of Dr. Young's optometer being, for convenience, only 8 inches long, and the inferior limit of distinct vision in a presbyopic eye being beyond that distance, Dr. Young applied to his instrument a convex lens of 4 inches focus, by which the point of distinct vision for such an eye was reduced within 8 inches from it: the numbers on his scale were therefore computed for the instrument when furnished with such a lens.

Dr. Young used the optometer for the purpose of determining the refractive powers of the eye, not only in its usual state, but also when, in cases of cataract, the crystalline lens had been displaced or extracted, and when the effect of the cornea had been rendered null by immersing the anterior part of the eye in water, which was contained in a cell of a proper form, and having a plane glass in front. By such means he endeavoured to ascertain in what manner the eye accommodates itself to distinct vision for objects at different distances from it; and his conclusion is that the faculty depends entirely upon changes of figure which take place in the crystalline lens. (*Lectures on Natural Philosophy*, vol. ii.)

ORA. [MONEY.]

ORACLE (from the Latin *oraculum*, and that from *os*, *or-is*, a mouth). Oracle was the Roman name used to denote the place where answers were supposed to be given by any of the divinities to those who consulted them respecting the future. Sometimes also it was used to signify the response which was delivered, and sometimes the deity from whom this response was imagined to proceed. Its primary and proper signification indeed is that of a response. Cicero ('Topic.,' 20) says that oracula were so called "quod inest in his Deorum Oratio." Those who were sent to consult them were sometimes called *oratores*. (Livy, v. 15.) Oracular responses were called *chresmi* (χρησμοί) or *manteia* (μαντεῖα) by the Greeks; the name *manteion* (μαντεῖον) was also often given to the oracular place, or the seat of the oracle.

Curiosity regarding futurity, and the desire to penetrate its mysteries, are dispositions which exert a powerful control over the minds of men in every stage of society; among nations that have made little advancement in civilisation and intelligence, they operate with peculiar force; and in these dispositions, combined with the belief that the gods had both the ability and the inclination to afford the knowledge so eagerly longed after, the oracles of the pagan world had their origin. Of these oracles the most famous were those of Greece, and among them that which had claims to the highest antiquity was the oracle of Zeus at Dodona. [DODONA, in GEOG. DIV.] But the most celebrated of the Grecian oracles was that of Apollo, at Delphi, a city built on the slopes of Parnassus in Phocis. [DELPHI, in GEOG. DIV.] Besides the oracles of Zeus and Apollo at Dodona and Delphi, that of Trophonius, near Lebadeia in Bœotia, may be mentioned, as having been held in high estimation. There were many other oracles in Greece, but of less repute.

Among the other most noted oracles of antiquity were that of Zeus Ammon in the desert of Libya, that of the Branchidæ in Ionia, of Pella in Macedonia, of Sinope in Paphlagonia, of the head of Orpheus at Lesbos, &c. Most of the heathen deities, and even the demigods and heroes, had oracles of their own. There were also current in Greece numerous so-called prophecies, the productions of individuals who were probably supposed to speak under a divine influence. Such were those of Bacis and Musæus, in which the battle of Salamis was predicted, and that of Lysistratus, an Athenian. (Herod., viii. 96.) But those productions are perhaps more appropriately considered under the head of PROPHECY, though Herodotus applies to them the same name (χρησμὸς) as to the responses from Delphi and other oracular places. As to the Sibylline oracles, see SIBYL.

Though the Romans had various modes of ascertaining the will of the deities, it does not appear that oracles like those of Delphi or Dodona were ever established among them; and we find that the oracles of Greece, and particularly the far-famed oracle of Delphi, were consulted by them on many important occasions. (Livy, v. 15; xxii. 57, &c.)

Among the Jews, the Urim and Thummim, which by an extraordinary brightness made known the will of Jehovah, bore a striking resemblance to the heathen oracles; and the oracle of Bathcol, or *daughter of the voice*, which was originated after the death of Malachi, was completely identical with them.

The modes in which oracular responses were delivered were very various. At Dodona they issued from the hollow of an oak; at Delphi they were delivered by the Pythia; and at the oracle of Ammon they were pronounced by the priests. At Memphis a favourable or unfavourable answer was understood to be returned, according as Apis received or rejected what was presented to him. [APIS.] Sometimes the reply was given by letter; and sometimes the required information could be obtained only by casting lots—the lots being dice with certain characters engraved on them, the meaning of which was ascertained by referring to an explanatory table. Dreams, visions, and preternatural voices also announced the will of the divinities.

The importance attached by the Greeks and Romans to oracular responses is a striking feature in the history of those people. Hardly any enterprise, whether public or private, of any moment, was undertaken without recourse being had to them and their sanction being obtained. In later times, indeed, their influence was greatly diminished, and thus gradually fell into disrepute. Cicero affirms that long before his age even the Delphic oracle was regarded by many with contempt; and there is little doubt that oracles were considered by philosophers as nothing different from what they really were, and by politicians as instruments which could be used for their purposes. The reply of Cato to Labienus, who wished him after the battle of Pharsalia to consult the oracle of Jupiter Ammon, embodies the opinion of that eminent Stoic respecting the propriety of thus questioning the gods. "On what account, Labienus, would you have me consult Jupiter? Should I ask him whether it would be better to lose life than liberty? Whether life be a real good? We have within us, Labienus, an oracle that can answer all these questions. Nothing happens but by the order of God. Let us not require of him to repeat to us what he has sufficiently engraved on our hearts. Truth has not withdrawn into these deserts; it is not engraven on the sands of Libya. . . . . Let the inconstant and those that are subject to waver according to events have recourse to oracles. For my part, I find in nature everything that can inspire the most constant resolution. The coward, as well as the brave, cannot escape death. Jupiter can tell us no more." (Lucan, 'Pharsalia,' lib. ix., v. 566–584.)

The question has been gravely discussed, whether oracular responses ought to be ascribed to mere human ingenuity and wisdom, or to diabolical agency. Most of the Christian fathers maintained that they ought to be ascribed to the latter. Allusion is made to this opinion in the first book of 'Paradise Lost,' where the spirits of Pandemonium are described as having taken possession of the various idols of the heathen world. There is nothing, however, in the history of the ancient oracles to countenance such a notion, or to lead to the belief that a supernatural cunning and skill directed them. Their replies to those who consulted them were for the most part obscurely and equivocally expressed, and so as to admit of different explanations, according as the wishes of the inquirer might suggest or the event determine; and even in those instances where trial was designedly made of the reality of their pretensions, it is not difficult to account for the success with which they stood the test, without calling in the assistance of demoniacal instrumentality.

Another circumstance respecting the oracles, which has given birth to much controversy, is, the time when they ceased altogether to give responses. Eusebius was the first who propounded the opinion that they became silent ever after the birth of Christ, and many writers, willing thus to do honour to the author of Christianity, have given it their support. Milton makes allusion to this theory also in the most magnificent of all his minor poems, 'The Hymn of the Nativity;' and in lines of solemn and elevated beauty, of which the following are the commencement, pictures the consternation of the heathen idols at the advent of the Saviour:—

"The oracles are dumb,
No voice or hideous hum
Rings through the arched roof in words deceiving.
Apollo from his shrine
Can no more divine,
With hollow shriek the steep of Delphos leaving.
No nightly trance or breathed spell
Inspires the pale-eyed priest from the prophetic cell."

But the circumstance that may thus be made available for the purposes of poetical ornament, happens unfortunately to be contrary to fact. It appears from the edicts of the emperors Theodosius, Gratian, and Valentinian, that oracles existed, and were occasionally at least consulted, till so late as A.D. 358. About that period they entirely ceased, though for several centuries previous they had sunk very low in public esteem. So few resorted to them, that it was no longer a matter of interest to maintain them. Towards this consummation Christianity powerfully contributed, by the superior enlightenment which it carried along with it wherever it was introduced, and by the display which it made of the falsehood and folly of the superstitions which it was destined to overthrow.

ORANGE. In the article CITRUS, in NAT. HIST. DIV., the different species of this genus have been described, as well as the more remarkable varieties of the orange. Being a native of warm southern latitudes, the orange is a remarkable instance of a fruit which gives employment and forms even an article of commerce from the southern to the more northern European nations. Thus, it is exported from Italy and Malta, as well as from the south of Spain and from Portugal, but in very large quantities from the Azores. Its cultivation is profitable not only on account of the esteem in which the fruit is held, but also from the extreme prolificness of the tree, so that the fruit is sold even in England at a price not much above and sometimes even for less than our own apples and pears.

Oranges are imported, as well as lemons, packed in boxes, and wrapped up separately in paper. The entries for home consumption, in 1859, amounted to 984,901 bushels.

The citron is considered to have been first cultivated in Italy by Palladius, in the 2nd century, but the orange not until the 14th century; it is probable, from the name, that it was introduced by the Arabs into Spain. Oranges bear the open air also at Nice, Genoa, and Naples, but at Florence and Milan, and often at Rome, they require the temporary protection of a shed. They are usually planted in boxes, and removed from the conservatory into the open air in summer, in France as well as in England; but since the introduction of the great variety of flowers from all countries, orangeries and fine specimens of orange and citron trees have been less in fashion, though none are more desirable on account of the combination of elegant verdure, the grateful odour of the flowers, and the rich appearance of the fruit. They have been cultivated in England since 1492: and Mr. Loudon states that at the Wilderness, Kent, there are three trees in boxes, not surpassed by any trees so grown in Europe; and that at Saltcombe, in Devonshire, there are in a few gardens orange-trees which have withstood the winter in the open air for upwards of a hundred years. They are propagated either by seeds, by cuttings, by layers, by grafting, or inoculation; and the orange thrives best when grafted on the lemon. The plants grown from seeds require so long to come to perfection, that they are seldom so propagated in England. The most regular and garden-like culture is in the orange orchards at Nervi, Monaco, and other places in the neighbourhood of Genoa. At the former are the orange nurseries which may be said to supply all Europe with trees, though the cultivation is of a very indifferent character, but the fine climate, strong clayey soil, and abundant manurings supply the place of more skilful treatment. Budding and grafting are performed in England at the usual season for such operations, but they may be performed at any time when the sap is in motion. In budding Mr. MacIntosh recommends that the cross cut should be made at the bottom of the slit in the bark instead of the top. Mr. Henderson, of Woodhall, one of the most successful growers of the Citrus tribe, has given a full description of the practices he adopts ('Caled. Hort. Mem.,' iii.; and Loudon's 'Encycl. of Gardening'); he considers cuttings as the quickest mode of getting plants. At Genoa and Florence the trees are grown in a strong yellow clay which is richly manured. The French, in preparing a compost, compensate for quantity by richness of manure. Henderson takes one part of light brown mould from a piece of ground that has not been cropped or manured for many years, one part of peat earth such as is used for growing heath, two parts of river-sand, or pit-sand, if it be free from mineral substances, and one part of rotted hot-bed dung, with one part of rotted leaves of trees, and mixes them all well together, so as to form a compact soil of uniform quality. The blood of animals is found to be valuable as a manure, and is improved by being mixed with mineral superphosphate of lime. Charcoal, not too finely broken, adds much to the health of the tree when mixed with the soil.

Orange-trees grow exceedingly well in pots and boxes, but they should be raised from the floor and well drained. The temperature of the soil required for producing fruit in perfection, is from a maximum of 85° to a minimum of 58°. In England the soil seldom reaches 66°, and often sinks to 36°; therefore, except in forcing-houses nothing can be expected from the plant but its flowers, the fruit if formed being small and tasteless. Yet the tree is hardy, and will live through an English winter if kept in the dark and dry. After the flowering, instead of allowing the wood to grow, continental gardeners clip them round into perfect globes with the hedge-shears. To use the knife would be better, but the practice is right; it rids the trees of superfluous matters, insures the maturing of the buds on the short branches left, the sap is thrown back into the buds, and thus elaborated into perfect flower-buds for the ensuing season. Trees so treated, and kept pretty dry from November till March, remain perfectly safe under an opaque roof. With us, the growing season is not favourable enough to ripen the wood without the aid of covering; and that, to insure health and abundance of bloom (the only thing to be sought for), must be transparent. These remarks apply to the lemon as well as to the orange.

Mr. St. John ('Travels in the Valley of the Nile') says, he saw a tree produced by joining the seed of the citron, the orange, and the lemon. The external coating being removed from one, this was placed between the other two, from which the coating of one side only had been removed. They were then bound together with a fine grass and planted; the result was a fruit combining beneath one rind, but distinctly marked both internally and externally, the qualities of the three species of which the seeds had been used.

(See the work of Risso of Nice, and Poiteaux of Versailles, *Histoire Naturelle des Oranges*, where 169 sorts are described, and 105 of them figured; also that of Gallezio, *Traité du genus Citrus*, who has given an account of the 40 different kinds cultivated in Italy; and Mr. Loudon's *Encycl. of Gardening.*)

ORANGE, LEMON, LIME—*Medical Properties of.* These are all species of the genus *Citrus.* Save the root, wood, and bark, every one of them yields from every part something of use in medicine or perfumery. *Citrus aurantium,* or sweet orange, is too well known to require description. Its leaves and unripe berries yield by distillation a fragrant oil called *essence de petit grain.* The small green unripe fruits of this species, and also of the *Citrus bigaradia,* or bitter orange, have an aromatic odour and bitter taste, and are used to flavour curaçoa. "When smoothed by a lathe, they form the issue peas of the shops." The flowers of the sweet, but still more the bitter, orange are distilled to yield orange-flower water, termed *aqua Naphæ.* This contains free acetic acid; this acid acts upon the lead in the joining of the stills in which it is prepared, or the leaden vessels in which it is imported; so that orange-flower water often contains a notable quantity of acetate or sugar of lead, giving rise to some troublesome decompositions when iodine or several other matters are mixed with it, as first pointed out by Mr. Squire. It is directed to be tested with hydrosulphuric acid, to ascertain its freedom from this contamination. Oil of orange-flowers, called *oleum Neroli,* is obtained by distillation of the flowers of the sweet and still more of the bitter orange. An inferior sort is got by expression of the grated rind.

The *Citrus medica,* or citron, yields two volatile oils, one termed essence or essential oil of citron, the other essence or essential oil of cedrat. This must not be confounded with cedrat, which is a liqueur or compound of the distilled oil of lemons and simple syrup. Neither must it be confounded with citronelle, or *eau de Barbades,* which is a West Indian distilled spirit of orange, lemon-peel, and aromatics, with proof spirit. *Crême des Barbades* is similar, prepared with rum. *Citronella Zeylanica,* or oil of lemon-grass, from Ceylon and the Moluccas, is obtained from the *Andropogon citratum,* a grass, not of the orange tribe. *Citrus bergamia* yields from the rind of the fruit, by either expression or distillation, the well-known essence or volatile oil of bergamot. This name is also applied to a volatile oil obtained from a mint, the *Mentha citrata* (or *M. odorata* of Sole, in his work on 'British Mints'), called bergamot mint. The volatile oil of the genuine bergamot is said by Liebig to differ, by containing oxygen, from the other oils of this genus, which are mere carburets of hydrogen. This similarity of chemical composition renders it difficult to distinguish mint oil from that of bergamot; but in all probability there is a difference in their polarising power or tendencies.

As stimulants, carminatives, and antispasmodics, these oils are occasionally used pure, on sugar, but mostly as constituents of tinctures and mixtures. Many of them enter into the composition of eau de Cologne, where ammonia seems the chief solvent. The pure oil of the lemon, either spirted or carefully dropped into the eye, has been used with benefit in chronic inflammation of that organ, whether of rheumatic or scrofulous origin, particularly where there is a tendency to the formation of specks of the cornea. It acts like the *Vinum opii.*

The fresh rind of the sweet orange, rasped, and pounded with three times its weight of loaf sugar till well incorporated, constitutes the *confectio aurantii* of the Pharmacopœia. The rind of the sweet, more frequently of the bitter, orange, occasionally of the citron, and even the lemon, is made into a conserve by having the pulp scooped out, then boiled, and boiled sugar poured over the rind.

The rind or peel of the sweet, but more frequently of the bitter, orange, and also the citron, are frequently candied and used at dessert, or the last in rich puddings, buns (Scotch), and short-bread. The rind or peel of the bitter orange, from which the soft, white, downy inside lining has been carefully stripped off, constitutes what is termed *Flavedo aurantii,* a wholesome stomachic. The bitter orange, termed Seville, is made in Scotland into a conserve called marmalade. The whole of the fruit, except the pips and inside lining (termed doff) of the peel, is used for this purpose, being boiled till the fruit is made quite tender; the skin is then to be cut into fine shreds (the finer the better, or rasped), and the whole boiled till it jellies. The flavour is greatly improved by using a few of the more fragrant-skinned sweet oranges along with the bitter. When properly prepared, this forms one of the most wholesome conserves at breakfast or dessert.

The skin of the sweet orange in the crude state is indigestible, and even dangerous. Children should be prevented eating it or swallowing the pips, as even fatal results have followed eating the rind of one orange. The pulp of the sweet orange, and, still better, the expressed juice, is very grateful to persons with feverish or inflammatory diseases. Orangeade is made by adding water and sugar to the juice. The adjunct of sugar is objectionable. Greatly more objectionable is sugar with lemon-juice, which is much more digestible when pure or diluted with water only. The utility of lemon-juice in exalting the digestive powers of the stomach was long familiarly known to gourmands, and taken by them as an accompaniment of young and fat meats, such as veal, lamb, pork, goose, and other food. These are almost all *white* meats; but in French cookery lemon-juice is taken with black meats, such as game. Ducks of different kinds are seasoned by the English with lemon-juice. It was, however, long before the observation of its power in these instances led to its employment to raise the depressed condition of the stomach among seamen and others compelled to use salted, hard, and innutritious meat for a length of time. To Sir Gilbert Blane is due the merit of this great improvement, which has almost entirely banished sea-scurvy from our navy. [ANTISCORBUTICS.] But many medicines have their curative power increased by the accompaniment of lemon-juice. Bilious and autumnal fevers of an intermittent type are often cured by cinchona with lemon-juice, which cinchona could not affect alone, or in other combinations. The most efficacious of antidotes to sea-sickness is lemon-juice alone, or with common table-salt dissolved in it. The health of many persons on land is very greatly improved by the habitual employment of lemon-juice at meals, in preference to malt liquors; but it must be taken without sugar. Of late lemon-juice has been recommended as a cure for rheumatism, in some cases with unquestionable benefit; but it requires to be taken in large quantity, and fresh, not old imported juice, or the imitation of genuine juice made by dissolving citric acid and adding tincture of lemon-peel. Headaches of a neuralgic kind and malarious origin are often speedily relieved by pure lemon-juice. Heartburn is often relieved by the same means. Slices of lemon applied to the skin by a bandage often cure cutaneous disorders. Lime-juice is used in the West Indies in the same way as lemon-juice. Both are much employed as ingredients in punch; but sugar is an objectionable accompaniment.

ORATO′RIO (Ital.), a sacred musical composition, consisting of airs, duets, &c., and choruses. The text is generally a dramatic poem, as Handel's 'Samson,' and Cimarosa's 'Sacrifizio d'Abramo.' Sometimes it takes the form of a narrative, as 'Israel in Egypt;' and occasionally it is of a mixed kind, as Haydn's 'Creation.' The 'Messiah' is a collection of passages from our received translation of the Scriptures.

Concerning the origin of the Oratorio, Dr. Brown, Sir John Hawkins, and others seem to have misunderstood the Père Menestrier, who, in his work 'Des Représentations en Musique,' attributes to the pilgrims, on their return from the Holy Land, not the introduction of what we term oratorios, as those writers suppose, but of the sacred dramas called 'Mysteries.' And the learned Jesuit is perhaps himself in error on this subject. It is Warton's opinion that about the 8th century the merchants who frequented the fairs, employing every art to draw numbers together, were accompanied by jugglers, minstrels, and buffoons, who were the source of great amusement to the people. The clergy, thinking that such entertainments tended to irreligion, proscribed them; but their censures and fulminations being disregarded, they took into their own hands the management of popular recreations—they turned actors—and, instead of profane mummeries, presented stories taken from legends or from the Bible. ('History of Poetry.') Voltaire conjectures that religious dramas came from Constantinople, where, about the 4th century, Gregory of Nazianzus, an archbishop, and one of the fathers of the church, banished plays from the stage of that city, and introduced stories from the Old and New Testament. As the ancient Greek Tragedy was originally a religious representation, a transition was made on the same plan, and the choruses turned into Christian hymns. "This opinion," says Warton, "will acquire probability, if we consider the early commercial intercourse between Italy and Constantinople." Admitting this, we need perhaps seek no further for the original source of the sacred musical drama.

As regards the more recent introduction of the oratorio, Crescimbeni, in his 'Comentarj,' tells us that it is attributable to San Filippo Neri, born in 1515, who, in his chapel,—('*nel suo oratorio*')—after sermons and other devotions, in order to allure young people to pious offices, and to detain them from earthly pleasure, had hymns and psalms sung by one or more voices. [NERI, in BIOG. DIV.] Bourdelot is rather more circumstantial on this subject. He says, S. Philippe de Nery, a native of Florence, founder, in 1540, of the congregation of the Priests of the Oratory in Italy, observing the taste and passion of the Romans for musical entertainments, determined to afford the nobles and people the means of enjoying them on Sundays and festivals in his church, and engaged for this purpose the ablest poets and composers, who produced dialogues in verse on the principal subjects of Scripture, which he caused to be performed by the most beautiful voices in Rome, accompanied by all sorts of instruments. These performances consisted of airs, duets, trios, and recitatives for four voices: the subjects were, Job and his Friends; the Prodigal Son received by his father; the Angel Gabriel with the Virgin; and the Mystery of the Incarnation. Nothing was spared to render these attractive, the novelty and perfection whereof drew a crowd of auditors, who were delighted with the performances, and contributed largely, by admission money, to the expenses incurred. Hence are derived what we now call oratorios, or sacred representations. ('Histoire de la Musique,' 1743, i. 256.) Some of these poems were printed, under the title of 'Laudi Spirituali,' and among the first authors of them was P. Agostino Manni. One of the most remarkable was entitled 'Rappresentatione di Anima e di Corpo, del Signor Emilio del Cavalieri, per recitar cantando.' It was the first attempt in the recitative style, and performed in action, on a stage erected in the church of Santa Maria della Vallicella at Rome, with scenes, dances, &c., as appears from the editor's dedication to Cardinal Aldobrandini, and the composer's instructions for the performance. From the latter Dr. Burney ('Hist.,' iv. 88) gives some curious extracts, among which are the following:—

The accompanying instruments—namely, a double lyre, a harpsichord, a large guitar, and two flutes—to be behind the scenes; but the performers are desired to have instruments in their hands, as the appearing to play would help the illusion.

The books of the words were printed. Instead of the modern overture, a madrigal, with all the parts doubled, and fully accompanied, is recommended.

When the curtain rises, two youths, who recite the prologue, appear. Then *Time*, one of the characters, comes on, and has the note with which he is to begin given him by the instruments behind the scenes. The *chorus* is to be placed on the stage, part sitting and part standing; and when they sing they are to be in motion with gestures.

Il corpo (the body), at the words *Si che hormai alma mia*, throws away his ornaments. The *World* and *Human Life* are to be gaily dressed, and when divested of their trappings are to appear poor and wretched, and finally dead carcasses.

The performance may conclude with or without a dance. If without, the last chorus is to be doubled in all its parts; but if a dance is preferred, a verse beginning "Chiostri altissimi" is to be sung, accompanied reverentially by the dance. During the ritornels the four principal dancers are to perform a ballet, *saltato con capriole* (danced with *capers*), without singing. They may sometimes use the *galliard* step, sometimes the *canary*, and sometimes the *courant*.

The name of *oratorios* was given, some think, to these performances, because they owed their birth to the *priests of the Oratory*. We are, however, more inclined to derive the term from the place, the *oratorio* (*oratorium*, oratory, or small chapel), in which they were first heard. But the word does not appear to have been in use till about the year 1630, when Balducci applied it to two of his sacred poems.

The unfortunate Stradella was one of the first of those who distinguished themselves in this exalted kind of composition [STRADELLA, in BIOG. DIV.]: his 'Oratorio di S. Gio. Battista,' produced about the year 1670, is analysed and much praised by Burney (iv. 105). A fine chorus from this, in five parts, is printed in the fourth vol. of 'The Fitzwilliam Music.' The increasing popularity of the sacred drama at length induced poets of eminence to employ their pens in its service. Apostolo Zeno, the imperial poet-laureate, produced seventeen works of this kind, under the title of 'Azioni Sacre,' most of which were set by Caldara, imperial vice-chapel-master to Leopold I., whose reputation as a composer of sacred music deservedly stands high. The first of them, 'Sisara,' was performed in 1717. Metastasio wrote seven 'Azioni,' of which Caldara set two; the first, 'La Passione,' in 1730. This was re-set by Jomelli, and is justly reckoned among the best of his works.

The oratorio was introduced into England in 1720, when Handel set 'Esther' (Racine's tragedy abridged and altered by Mr. Humphreys) for the chapel of the Duke of Chandos (Pope's 'Timon') at Cannons. This, in 1731, was performed by the children of the Chapel Royal, at the house of their master, Bernard Gates. The next year it was publicly produced, as appears from the following advertisement in the 'Daily Journal:'—"By his Majesty's command, at the King's Theatre in the Haymarket, on Tuesday, the 2nd of May, will be performed the sacred story of 'Esther,' an oratorio in English, formerly composed by Mr. Handel, and now revived by him, with several additions, and to be performed by a great number of voices and instruments. N.B. There will be no acting on the stage, but the house will be fitted up in a decent manner for the audience." The success of this was of the most decided and encouraging kind; but for an account of the great master's other oratorios, and of his inducement for first producing them, we refer to the life of HANDEL, in the BIOG. DIV. of this work.

The custom of performing oratorios on the Wednesdays and Fridays in Lent is to be dated from 1737, from which time they were, with few intermissions, continued till a very recent period. Handel was succeeded in this musical speculation by his friend J. C. Smith, who was followed by Stanley and the elder Linley. [STANLEY, and LINLEY, in BIOG. DIV.] Linley and Dr. Arnold then in conjunction most successfully carried on the oratorios, which were continued by the latter on the retirement of his colleague. [ARNOLD, in BIOG. DIV.] An opposition was now started by Ashley, who had been active as a subordinate agent at the Commemoration of Handel in 1784. This person soon transformed the performances into secular and often vulgar concerts, though retaining the original name; and from that time the oratorios began to degenerate, till at length, having been for some years carried on by different persons, and generally at a loss, they ceased altogether. Though it would be unjust not to admit that, even during this unfavourable interval, there were two or three seasons that reflected some credit on the managers, in which 'The Messiah,' with Mozart's added accompaniments, was first publicly produced in London, and also Beethoven's 'Mount of Olives.' Of late years, chiefly through the exertions of the Sacred Harmonic Society, oratorios have been restored to more than their early popularity in this country, and are probably performed with more power, feeling, and precision than at any previous period. The oratorios of Mendelssohn have contributed not a little to this work. [MENDELSSOHN, in BIOG. DIV.]

ORATORY. The principal design of oratory is to convince or persuade. It contemplates the investigation of truth only as a secondary object. Assuming as its basis certain supposed or admitted principles or facts, its aim is, by presenting these in the form best adapted to win the assent of the understanding and impress the heart, to deter from or incline to a particular mode of resolution and action. This, the chief end of oratory, ought never to be left out of sight in any disquisition on that subject, inasmuch as upon it the general theory of the art is founded.

The oratorical art has been always held in high estimation; among the ancient Greeks, as among the rudest savages, the possession of eloquence has ever conferred a high degree of power on its possessor. Eloquence, however, does not consist in the observance of artificial rules; such rules are rather deduced from an examination of the qualities of eloquence, which depends upon peculiar mental powers, and is included in what is often termed genius, such as has distinguished many of the orators of antiquity, and some of modern times. The practice of reading, of delivery, and the improvement of the memory, should be diligently attended to by the orator. This constitutes the art of elocution, of which we now propose to treat.

Elocution is that pronunciation which is given to words when they are arranged into sentences and form discourse. It includes the tones of voice, the utterance, and enunciation of the speaker, with the proper accompaniments of countenance and gesture. The art of elocution therefore may be defined to be that system of rules which teaches us to pronounce written or extemporaneous composition with justness, energy, variety and ease; and agreeably to this definition, good reading or speaking may be considered as that species of delivery which not only expresses the sense of the words so as to be barely understood, but at the same time gives them all the force, beauty, and variety of which they are susceptible.

The Greeks and Romans paid great attention to the study of elocution, and there can be no doubt that their most celebrated orators attained to a high degree of excellence in this branch of their art; but they have left nothing on record which shows that they had made a minute analysis of the speaking voice. They did indeed distinguish its different qualities by such terms as hard, smooth, sharp, clear, hoarse, full, slender, flowing, flexible, shrill, and rigid. They were sensible to the alternations of heavy and light in syllabic utterance: they knew the time of the voice, and regarded its quantities in pronunciation: they gave to loud and soft appropriate places in speech: they perceived the existence of pitch, or variation of high and low; and noted further that the rise and fall in the pronunciation of individual syllables are made by a *concrete* or continuous slide of the voice as distinguished from the *discrete* notes produced on musical instruments. They designated the pitch of vocal sounds by the term *accent*, making three kinds of accents, the acute, the grave, and the circumflex, which signified severally the rise, the fall, and the turn of the voice, or union of acute and grave on the same syllable. But beyond this they did not go, and it was left to modern inquirers to give that clear and full description of the elements of speech, on which alone any definite instruction can be founded. For the advance which has been made in elocutionary science in modern times we are indebted to the useful labours of Steele, Odell, Walker, Thelwall, Chapman, Smart, and Rush, especially to the last, who has done much to perfect what was begun by others, and whose 'Philosophy of the Human Voice'[*] contains a more minute and satisfactory analysis of the subject than is to be found in any other work. From his book chiefly we shall borrow the substance of this article.

When the letter *a*, as heard in the word *day*, is pronounced simply as an alphabetic element, without intenseness or emotion, and as if it were a continuation and not a close of utterance, two sounds are heard continuously successive: the first has the nominal sound of this letter, and issues from the organs with a certain degree of fulness; the last is the element *e*, as heard in *eve*, which gradually diminishes until its close. During the pronunciation, the voice rises, by the concrete or continuous movement, through the interval of a tone, the beginning of the *a* and the termination of the *e* being severally the inferior and superior extremes of that tone. This sound commences full and somewhat abruptly, and gradually decreases in its upward movement, till it finally dies away in the upper extreme of the tone, having the increments of time and rise, and the decrement of fullness, equally progressive. The first portion therefore, or base of this sound, is called the *radical movement*, and the second portion the *vanishing movement*. This sound is called a concrete, or slide, to distinguish it from musical sounds, which (in their *pure* character) continue for a given space of time on a certain point of the scale, and then leap, as it were (*discretely*), to another point either higher or lower. These slides may extend through the space of a tone, or they may be carried up to any point on the scale to which the voice can attain, those intervals which are the most distinctly recognisable by the ear and the most easy of execution being the tone (or second), the third, the fifth, and the octave. The direction also which they take may be either upwards or downwards, the full opening radical however always occupying the first place, and the vanish the second. It also frequently happens that there is a union of the upward and downward, or of the downward and upward movement, on the same syllable: these are called *waves* or *circumflexes*; they may rise and fall through the extent of a tone, or of a third, or of any wider interval of the scale; they are then called *direct* waves: or they may fall and rise through the same extent of pitch, being then called *indirect* waves; they may be *equal*, having their constituent rise and fall through the same extent of pitch; or they may be *unequal*, having either the ascent or the descent longer than the other part.

The succession of the seven sounds of any one series, to which the octave is usually added, is called the Natural or Diatonic Scale. In speech, as in music, it consists of five tones and two semitones, the latter being the spaces between its third and fourth and its seventh and eighth degrees. But a progression may also be formed by semitones: these have only half the extent of pitch which the full tones have: like them, they may be carried upwards or downwards, and they often occur in the form of waves. They serve for the expression of animal distress.

But the succession of discrete sounds may be exhibited under still more minute divisions. These consist of a transition from place to place in pitch, over intervals much smaller than a semitone, each point being, as it were, rapidly touched by a short and abrupt emission of voice. This description may be illustrated by that noise in the throat which is called *gurgling*, and by the neighing of a horse. The analogy here regards principally the momentary duration, frequency, and abruptness of sound, for the gurgling is generally made by a quick iteration in one unvarying line of pitch, whereas in the scale now under consideration each successive pulse of sound is taken at a minute interval above the last, till the series reaches the octave. The precise extent of these small intervals it is very difficult to estimate. They may however be carried concretely through the wider interval of the scale, provided they do not lose their distinctive character of momentary time and abruptness of utterance. These concretes are used both in laughter and in crying. In the descending scale, the direction not only of the radicals but of the vanishes is downwards. *Intonation* is the act of performing the movements of pitch through the several scales.

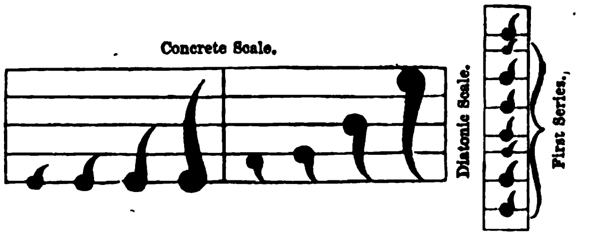
There are then *four* scales of pitch for the speaking voice:—

1. The *Concrete*, in which from the outset to the termination of the voice there is no appreciable interval, or interruption of continuity.

2. The *Diatonic*, the transitions of which are principally by whole tones.

3. The *Semitonic*, or *Chromatic*, consisting of an entire succession of semitones.

4. The *Tremulous*, consisting of minute intervals smaller than the semitone.



The *alphabet* is, in our grammars, usually divided into vowels, consonants, mutes, and semivowels; but it will be more useful to class the elements according to their use in intonation. As the number of these elementary sounds in the English language exceeds the literal signs, and some of the letters are made to represent various sounds without any rule of discrimination, it is necessary to use short words of known pronunciation, containing the elementary sounds, with the letters which represent them marked in italics. The elements of articulation are thirty-five, and they may be arranged under three general heads.

1. The first division embraces those sounds which display the properties of the radical and vanish in the most perfect manner. They are twelve in number, and are heard in the usual sound of the separated italics in the following words:—*a*-ll, *a*-rt, *a*-n, *a*-le, *o*-ur, *i*-sle, *o*-ld, *ee*-l,

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[*] Second edition, 8vo, Philadelphia, 1833. See also Mr. Steele's 'Essay towards establishing the Melody and Measure of Speech, to be expressed and perpetuated by peculiar symbols,' London, 1775. The second edition was published in 1779, with the title of 'Prosodia Rationalis.' Mr. Odell's work is entitled 'An Essay on the Elements, Accents, and Prosody of the English Language,' 12mo, London, 1805.

ou-ze, *e*-rr,* *e*-nd, *i*-n.† From their forming the purest and most plastic material of intonation, these are called *Tonic* sounds. They have a more musical quality than the other elements; they are capable of indefinite prolongation; admit of the concrete and tremulous rise and fall through all the intervals of pitch, and may be uttered more forcibly than the other elementary sounds, as well as with more abruptness.

II. The next division includes a number of sounds possessing variously among themselves properties analogous to those of the tonics, but differing in degree. They amount to fourteen, and are marked by the separated italics in the following words:—*B*-ow, *d*-are, *g*-ive, *v*-ile, *z*-one, *y*-e, *w*-o, *th*-en, a-*z*-ure, si-*ng*, *l*-ove, *m*-ay, *n*-ot, *r*-oe.

From their inferiority to the tonics in all the emphatic and elegant purposes of speech, whilst they admit in some measure of being intonated, or carried concretely through the intervals of pitch, they are called *subtonic* sounds.

III. The remaining nine elements are aspirations, and have not that sort of sound which is called vocality. They are produced by a current of the whispering breath through certain positions of the enunciative organs. They are heard in the words—U-*p*, ou-*t*, ar-*k*, i-*f*, ye-*s*, *h*-e, *wh*-eat, *th*-in, pu-*sh*.

As they admit of little or no pitch, and supply no part of the concrete when breathed among the constituents of syllables, they are termed the *Atonic* sounds.

The name of *Abrupt* sounds is also given to three of the subtonics and three of the atonics, namely, *b, d, g, p, t, k*, since they confer an *explosive* character on the following tonic, the breath bursting out after a complete occlusion.‡

In conformity to the above division of the letters, and with especial reference to the time which is occupied in pronunciation, syllables are divided into three classes—1st, *Immutable*, such as *at, ap, ek, hap*-less, *pit*-fall, ac-*cep*-tance; 2nd, *Mutable*, as *yet, what, grat*-itude, des-*truc*-tion; 3rd, *Indefinite*, as *go, thee, for, day, man, till*, de-*lay*, be-*guile*, ex-*treme*, er-*ro*-neous. It is the peculiar nature of this last class of syllables, that to whatever necessary degree their quantity is prolonged, their character is still preserved, while the mutable and immutable in some cases almost lose their identity by too great an addition to their time. The use of these distinctions will appear in the sequel.

Thus much having been premised, it will be the more easy to understand the general divisions of vocal sound. All the varieties of sound in the human voice may be referred to the following general heads:—

Quality, Force, Time, and *Pitch.*§

I. The terms by which the *Quality* or kind of voice is distinguished are rough, smooth, harsh, full, thin, slender, soft, musical, and some others of the same metaphorical structure.

There are three different sorts of voice, the *natural*, the *falsette*, and the *orotund*, to which must be added the *whisper*, which, strictly speaking, is not *voice*. The *natural* is that which we employ in ordinary speaking. It includes a range of pitch from the lowest utterable sound up to that point at which the voice is said to break. At this point the natural voice ceases, and the higher parts of the scale are made by a shriller kind, called the *falsette*, of which the cry, the scream, the yell, and all shrillness are various modes. The name of *orotund* (from *os rotundum*) is given to that natural or improved manner of uttering the elements, which exhibits them with a fulness, clearness, strength, smoothness, and a ringing or musical quality rarely heard in ordinary speech, and which is never found in its highest excellence except as the effect of long and careful cultivation. This voice is highly agreeable to the ear; it is possessed by actors of eminence, and is peculiarly adapted to set forth the beauties of epic and tragic composition. The *whisper* is the constituent of the atonic elements; but all the tonics, and the greater part of the subtonics, may likewise be uttered in this mode of sound. The subtonics *v, z, w, th*-en, *zh*, when whispered, are not respectively different from the atonics *f, s, wh, th*-in, *sh*.

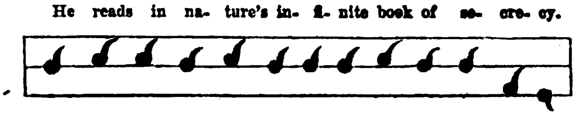
II. For the specifications of *Force* we use the words strong, weak, feeble, loud, soft, forcible, and faint. These are indefinite in their indication, and without any fixed relationship in degree.

III. *Time*, in the art of speaking, is divided into long, short, quick, slow, and rapid. These distinctions may suffice for the common purposes of discourse; if more precision is required, a notation will be found in Mr. Steele's 'Prosodia Rationalis.' The distinction of immutable, mutable, and indefinite syllables has reference to time, and has been already treated of.

IV. The meaning of the term *Pitch*, as applied to speech, has been already explained.

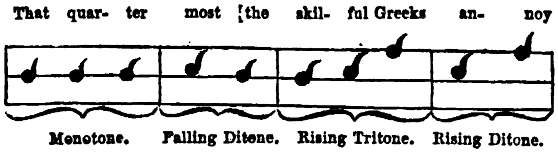
We come now to the application of these elements and distinctions to the practical purposes of reading and speech.

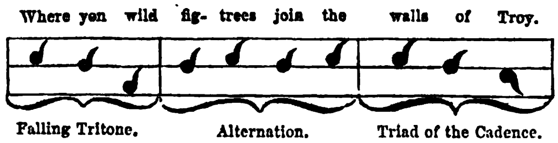
In plain narrative or description, the concrete utterance of each syllable is made through the interval of a tone, and the successive concretes have a slight difference of pitch relatively to each other. The appropriation of these concretes to syllables, and the manner in which the succession of their pitch is varied, are exemplified in the following notation:—



If these lines and the enclosed spaces be supposed, each in proximate order, to denote the difference of a tone in pitch, the successions of the radical points, with their issuing vanish, will show the places of the syllables of the superscribed sentence in easy and unimpassioned utterance, though it is not denied that a somewhat different arrangement might also be agreeable. The perception of the successions here exemplified is called (in a restricted meaning of the term) the melody of speech.

In simple phraseology, which conveys but little feeling or emphatic sentiment, most of the syllables, except one or two of the last in the sentence, consist of the upward radical and vanishing tone. The succession of these concrete tones is made with a variation of pitch, in which any two proximate concretes never differ from each other more than the interval of a tone, nor do there occur more than three successive tones in one direction either upwards or downwards. This is called the *diatonic melody*. The rise of each separate syllable is called the *concrete pitch* of melody, and the place which each syllable assumes above or below the preceding, the *radical pitch*. The *current* melody of sentences in plain discourse admits of considerable variety, but the forms of radical pitch are all reducible to a limited number of aggregates of the concrete tones, which may be called the *phrases of melody*. Their forms are pointed out in the notation of the following lines:





The *melody of the cadence*, as distinguished from the current melody, is formed on the two or three last syllables of a sentence, and is effected by a descent of radical pitch through three conjoint degrees, with a downward concrete always on the last, and frequently on the preceding. One form of the cadence has been illustrated in the sentence, the notation of which has been given above; but there are various forms according to the component parts and the sense.

Plain declarative sentences generally take one form or other of the cadence, in order to mark the satisfactory close of the period; and downward concretes are also frequently introduced into what are called loose sentences, to denote that the sense is complete, and that the succeeding clause does not modify that which precedes it. Where, on the contrary, the sense is suspended, as it most commonly is in the middle of a sentence, the concretes must have an upward direction.

For conveying the peculiarities of sentiment or feeling, or, in other words, for the *expression of speech*, a much more varied apparatus is necessary. This expression is effected by quality, time, pause, melody, pitch, the waves, the semitones, the tremor, force, and rhythm, all which are only so many forms of the four general divisions of vocal sound above specified.

I. Most of the elements which range under the general head of *Quality* have already been enumerated. It must, however, be remarked that they are susceptible of combination with the various modes and degrees of force, time, and pitch. In short, quality of voice must necessarily be united with some of the degrees of the other genera; for, whatever be the kind, it will be either strong or weak: its time must be long or short; and it must be of some definite radical or concrete pitch. Certain qualities of the voice are, however, exclusively congenial with particular conditions of these other accidents; thus smoothness will more generally affect the moderate degrees of force.

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* The writer of this article has personal opportunity of knowing that by this word Dr. Rush meant to designate that sound which Mr. Cull represents by *her*.

† If *oi* or *oy*, as in *voice* and *boy*, be added as perhaps they ought, the number of the tonics will be thirteen.

‡ It is difficult to decide on the analysis of the elementary sounds represented by the alphabet. That of Dr. Rush is given in the text. The following has been furnished to the writer of this article by Mr. Cull, and, although not free from objections, is more complete.

I. Vowels, as heard in the following syllables:—*a*ll, *a*rm, *a*n, *a*le, *e*nd, *ee*l, h*e*r, *i*sle, *i*n, *o*ld, *oo*ze, *o*n, *u*s, c*u*be, p*u*ll, *ou*r, *oi*l.

II. Consonants. 1. *Voice Consonants:*—*b*e, *d*o, *g*o, *l*o, *m*e, *n*o, *r*oe, *v*at, *w*e, *y*e, *z*one, si*ng*, a*z*ure, *th*en, *j*ew. 2. *Voiceless Consonants:*—u*p*, a*t*, ar*k*, i*f*, *h*ope, *qu*it, *s*in, *ch*in, *sh*in, *th*in, *wh*en. In all forty-three elements.

§ To these Dr. Rush adds a fifth, namely, *Abruptness;* but this appears to be resolvable into force and time.

II. *Time*.—The degrees of duration of the voice represented by the terms long, short, and the rate by quick and slow, are among the most effective means of expression; rage, mirth, raillery, and impatience affecting a quick time; and slowness of time being the symbol of sorrow, grief, respect, veneration, dignity, apathy, contrition, and all other sentiments which embrace the idea of deliberation. A slow time of discourse, if not made by long quantities on single syllables, would be offensive from its pauses; these two forms of time therefore necessarily involve each other. Slowness of time and long quantity are generally joined with the element of the wave, since the return, or contrary flexure of intervals, is one of the means for producing an extension of time without destroying the equable concrete of speech, or, in other words, without passing into song. The wave of a tone will be perceived in the dignified and appropriate utterance of the syllables marked in italics in the following lines:—

> " *Par*don me, thou *bleed*ing piece of earth,
> That I am meek and gentle with these butchers."
>
> " *Hail*, *ho*ly light, offspring of heaven, first-*born*,
> Or of the *eter*nal, *co*-eternal beam,
> May I express thee, *unblamed?* "

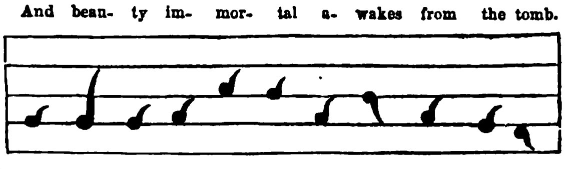
III. The use of *pause* for the more conspicuous display of sense and sentiment, by separating certain words or aggregates of words from each other, is of great consequence in elocution, but cannot be gone into at length in this article. To these pauses the grammatical points are by no means a sufficient guide. [PUNCTUATION.]

IV. A comprehensive account of *Melody* would properly represent it as produced by a variation in the time, pauses, force, and pitch of the voice, since the well-appointed uses and dispositions of these accidents make up the agreeable impression of speech; but we use it here as relating solely to the successions of radical pitch. Under this head it may be remarked that a predominance of the *monotone* is suited to feelings of dignity, grief, tenderness, solemnity, and serious admonition; that the *alternate phrase* well describes the earnest excitement necessarily produced by the rapid succession of incident; and that a *progression* gradually rising and falling through *the whole compass of the voice* corresponds with a wide variation of force in the sentiment. For illustrations of these modes see Dr. Rush's 'Philosophy of the Voice,' pp. 112, 144.

V. *Pitch.*—Discrete pitch is illustrated by the word *must* in the following passage. As it is a syllable which does not admit of prolongation, it is raised discretely a third above the preceding:—

> "If I *must* contend, said he,
> Best with the best, the sender, not the sent."

We have an example of a *concrete* rising *fifth* on *beau-*, and of a *discrete third* on *mor-*, in the following:—



If we suppose that the following words are spoken *interrogatively*, and that they express surprise, the concrete rising fifth must be given to the emphatic syllables:

Give Brutus a statue with his ancestors?

If, on the other hand, the line be read as a *command*, the direction of the concretes will be downwards.

On the word *know*, in the following clause, not only does the voice descend concretely a third or a fifth, but the descent begins discretely a third above the preceding word:—

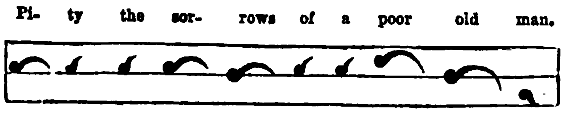
We know what we worship, for salvation is of the Jews.

As the diatonic melody is suited to plain narration and description, so will the emphasis be the more strongly marked in proportion to the wider extent of the intervals, whether of concrete or discrete pitch, which are employed. It may also be remarked in general, that the upward concretes denote interrogation, doubt, or what is concessive, conditional, hypothetical; the downward concretes denote what is strong, certain, authoritative, as also, wonder, admiration, surprise, and exclamation, when not conjoined with an interrogative meaning.

VI. *The wave* is a very frequent element of expression, and performs high functions of speech. In its minor forms it is used to give length and emphasis to syllables and dignity to utterance: in its wider intervals it is admirably expressive of irony and derision. Thus the irony of the following passage can be brought out only by the indirect wave of a fifth in both places in which it occurs:—

> But it is foolish in us to compare Drusus Africanus and ourselves with Clodius: all our other calamities were tolerable, but no one can patiently bear the death of Clodius.

VII. *The semitones.*—These are used for the expression of complaint, pity, grief, plaintive supplication, and other sentiments congenial with these. The intonation by the concrete is universally the symbol of nature for animal distress. It affects generally a slow time and long quantity in utterance, and is therefore most commonly heard in the form of the wave. The interjective exclamations of pain, grief, love, and compassion, are prolongations of the tonic elements on this interval; but it may be executed on the short time of immutable syllables, such as *cup.* The appropriate utterance of the following line will exhibit the wave of the semitone on the most important syllables, *poor* and *old* being distinguished by direct unequal waves of the same interval. It must be taken as an isolated line, and not in conjunction with the verse of which it forms part:—



VIII. *The tremor.*—When the tremulous function is made through the second, third, fifth, or octave, or through the wave of these intervals, it joins the sentiment of derision, mirth, joy, or exultation, to that of interrogation, surprise, command, or scorn, conveyed by the smooth concrete of those intervals. In short, it is the introduction into speech of what is transferable in the function of laughter, and it adds thereto all the meaning and force of its satisfaction. Thus—

> " Thou art the ruins of the *no*blest man,
> That ever lived in the tide of times."

There is a sentiment of exultation and a superlativeness of compliment in this eulogy, which cannot be properly expressed by the smooth movement of the concrete; but if the first syllable of the emphatic word *noblest* be uttered with the tremulous intonation of the wave of the third or second, this will give the vocal consummation to the feeling which suggests the exceeding measure of the praise.

The *chuckle* is an example of a somewhat similar application.

When the tremor is formed of a single tonic, in the semitone or its waves, it constitutes the function of crying; and when employed in the syllabic intonation of the chromatic melody, it sets a more marked distinction on those emphatic words which express the sentiments of tenderness, grief, supplication, and other connatural states of feeling. This may be illustrated on the emphatic syllables of the line just quoted:—" Pity the sorrows," &c.

IX. The application of the different degrees of *Force* to the purposes of expression is almost too obvious to require illustration. Thus the *distance* of a person spoken to is pictured by loudness, and *nearness* by abatement of force; *secrecy* muffles the voice against discovery, and *doubt* adopts the subterfuge of an undertone. *Certainty* and *anger* assume force and strength. All sentiments which are *unbecoming* or *disgraceful* smother the voice into softer degrees, in the desire to conceal even the voluntary utterance of them. *Joy* is loud, and so are *bodily pain*, *fear*, and *terror*.

Such are some of the uses of force when applied to phrases, or to one or more sentences, in order to distinguish them from adjacent phrases or sentences in discourse. There are other applications of it, to single words, to syllables, and to certain parts of the concrete movement, into which, though of some consequence, it is not within the purport of this article to enter. They will be found described in Dr. Rush's 'Philosophy of the Voice.'

The common idea of *Emphasis*, it may be remarked, is that of mere force; but it is more correctly defined to be the expressive but occasional distinction of a syllable, and consequently of the whole word, by one or more of the specific modes of time, quality, force, and pitch. Most of these have been illustrated under the above heads.

X. *Rhythm* is one of the applications of force and quantity. It may be defined to be the metrical arrangement of speech. It is not mainly dependant on custom or on the genius of any language whatever, but arises from the very manner in which speech is produced, and is as involuntary as the throb or remission of the pulse, or the inhaling and respiration of the breath. In the formation of speech there is a regular action and reaction of the organs which produce it. To form a *heavy* syllable, or one which has accentual stress upon it, these organs are necessarily placed in a certain position; and from their very nature it is necessary that, before they form another heavy syllable, they should recover their first position; but the time which is occupied in this recovery of their position is not always lost to the purposes of speech, for it may be filled up with one or more syllables, which have no stress, and which are therefore very properly denominated *light;* if it is not filled up in this way it is a pause or rest. To illustrate this, let us take the words—

One, two, three, four, five.

These monosyllables, if distinctly and deliberately pronounced, have two peculiarities; each has the organic stress or emphasis, and each has a pause after it. Let these pauses be filled up with the light syllable *and;* and then the two lines, namely:—

One and two and three and four and five and

and

One, two, three, four, five,

will be of exactly the same length as to time in music, or rhythm in speech, the syllable *and* occupying no more time than what necessarily intervenes between the syllables under organic emphasis.

This alternate action and reaction of the organs of speech was called by the Greeks by the significant terms *Thesis* and *Arsis;* the former denoting the *setting down* of a syllable, as the setting down of the foot in walking; the latter denoting the *raising of it up,* like the lifting of the foot from the ground; the former producing the heavy syllables, the latter the light ones.

The weight of syllables, or in other words, the stress with which they are enunciated, must be carefully distinguished from their quantity, since the weight or stress with which the syllable is uttered does not always correspond to the relative time which the utterance requires. Thus in the word *pensive,* the syllable *pen* is the heavier, but it is not longer than the syllable *sive.* So also in the word *inward,* there is an equality of time in the two syllables, but not of weight. In *banish, banner, banter,* the first syllable is heavy but short; in *paper, taper, vapour,* it is both heavy and long; and the same observation applies to *misery, middle, mistress,* compared with *miser, minor, mitre.*

Those emphatical divisions into which, from the very nature of the organs, all speech naturally falls, are called by writers on this subject *cadences.*[*] Every full *spoken* cadence consists of a heavy syllable, and of one or more light ones, but pauses may be substituted to make up the time which any of these syllables would occupy. Measure, or metre, therefore in speech naturally distributes itself into two kinds: common measure, which, according to Mr. Steele, is the allotment of two crotchets or their equivalents to each cadence; and triple measure, which is the allotment of three crotchets or their equivalents to each cadence; emphasis however will sometimes prolong the duration of a cadence beyond the allotted time, just as an *ad libitum* is allowed in solos in music. Without entering further into minute distinctions or exceptions, the following may serve as specimens of each kind. This mark § indicates a short pause, this ‖ a longer, and this ¶ a still longer one:—

COMMON MEASURE.

"So § | spoke the | guardian | § of the | Trojan state, |
‖Then | rush'd im- | petuous § | through the | Scæan | gate; |
‖Him | Paris | followed | § to the | dire a- | larms: |
Both § | breathing | slaughter, § | both re- | solv'd in | arms." |
Pope's *Iliad,* b. vii.

"Straight mine | eye § hath | caught new | pleasures, |
Whilst the | landscape | round § it | measures, |
Russet | lawns § and | fallows | grey, |
Where the | nibbling | flocks § do | stray; |
Mountains § | on whose | barren | breast
The | labouring | clouds § do | often | rest." |

TRIPLE MEASURE.

"‖§At the | close of the | day § when the | hamlet is | still, §
And | mortals § the | sweets of for- | getfulness | prove; ‖ |
¶When | nought but the | torrent § is | heard on the | hill, §
And | nought but the | nightingale's | song § in the | grove." ‖ |

If this system of measuring verse were adopted, the prosody not only of our own but of the learned languages would be greatly simplified. The list of feet which is usually given at the beginning of the 'Gradus ad Parnassum,' would be reduced to four or five; we should hear of no such unnatural foot as an iamb or an anapæst, and the syllable at the beginning of an iambic line would either of itself form a cadence, or would be the close of a cadence, of which a pause or the last syllable of the preceding line would form the commencement. Those lines of Anacreon would then be reduced to the trochaic measure, thus:—

‖θελ- | ω λε- | γειν Ἀ- | τρειδας, |
‖θελ- | ω δε | Καδμον | ᾀδειν, |
§ἁ | βαρβι- | τος δε | χορδαις |
‖ε- | ρωτα | μουνον | ηχει. |

From the above examples it is clear that there is a regular rhythmus in poetry; and it cannot be necessary to insist on this being strictly attended to, if we would read verse in an agreeable and expressive manner. Prose also has its rhythmus, for the alternate action and reaction of the organs of speech necessarily proceeds, whether what is spoken be prose or verse; and the only difference (so far as sound is concerned) between these two species of composition is, that verse consists of a regular succession of similar cadences, or of a limited variety of cadences, divided by grammatical pauses and emphasis into proportional clauses, so as to present sensible responses to the ear at regular proportioned distances; prose, on the other hand, is composed of all sorts of cadences, arranged without attention to obvious rule, and divided into clauses which have no obviously ascertained proportion, and present no responses to the ear at any legitimate or determined intervals.

There is nothing which contributes more to the rhythmical flow of prose than giving a light sound to monosyllables. If this be done, they then form the latter part of cadences, of which either pauses, or emphatical monosyllables, or the emphasised syllables of longer words form the beginning; but if they be pronounced heavy it is then necessary that they should themselves form the beginning of new cadences, which is the occasion of many pauses being introduced, and of a heavy and halting character being communicated to the piece. Thus the clause "Let not your | heart be | troubled," | will be rhythmical if *your* be thus made a light syllable; but the effect will be very different if it be read thus:—"Let not | your § | heart be | troubled."

Of the advantage of cadences in triple measure we have a beautiful illustration in the first verse of the 136th Psalm:—

‖ "O | give ‖ | thanks unto the | Lord; ‖ | § for he is good, ‖ | ‖ for his | mercy en- | dureth for | ever." ‖ |

On the other hand, a succession of heavy syllables, with a pause intervening, is one of the most expressive forms of emphasis both in prose and verse. Thus the following line from Milton would lose all its force, if read so as to form only the usual number of six cadences; emphasis prolongs it to eight, thus:—

"Rocks, ‖ | caves, § | lakes, § | fens, ‖ | bogs, ‖ | dens and | shades of | death." ¶ |

Independently of its agreeable effect upon the ear, and its power as an element of expression, there can be no doubt that, as rhythm arises from the very manner in which speech is produced by the organs, he who speaks agreeably to its laws will speak easily to himself. The practice of reading or speaking aloud, with a due attention to the rhythmus, may even be recommended as a means of improving the health, since it brings into regular and natural action the muscles of the face, the throat, and the chest; and no attempt completely and permanently to remove impediments of speech can be successful which is not based on the principle here developed.

(A succinct account of rhythm will be found in Wood's *Grammar of Elocution,* ch. iv. and v.; and the subject is treated much more at length in Steele's *Prosodia Rationalis;* in Thelwall's *Illustrations of English Rhythmus;* in Roe's *Principles of Rhythm;* and in Chapman's *Music, Melody, and Rhythmus of the English Language,* 8vo, Edinburgh, 1819; as well as in his *Rhythmical Grammar,* 12mo, 1821.)

In order to read and speak well, it is necessary to have all the vocal elements under complete command, so that they may be duly applied whenever they are required for the vivid and elegant delineation of the sense and sentiment of discourse. The student therefore should first practise on the thirty-five alphabetic elements, in order to ensure a true and easy execution of their unmixed sounds. This will be of more use than pronouncing words in which they occur; for when pronounced singly, the elements will receive a concentration of the organic effort, which will give them a clearness of sound and a definite outline, if we may so speak, at their extremes, making a fine preparation for their distinct and forcible pronunciation in the compounds of speech. He should then take one or more of the tonic elements, and carry it through all the degrees of the diatonic and concrete scales, both in an upward and a downward direction, and through the principal forms of the wave. He should next take some one familiar sentence, and practise upon it with every variety of intonation of which it will admit. He should afterwards run through the phrases of melody, and the forms of the cadence; and lastly he should recite, with all the force that he can command, some passage which requires great exertion of the voice. If he would acquire power and volume of utterance, he must practise in the open air, with his face to the wind, his body perfectly erect, his chest expanded, his tongue retracted and depressed, and the cavity of his mouth as much as possible enlarged; and it is almost unnecessary to add that anything which improves the general tone of the health will proportionably affect the voice. If to this elementary practice the student add a careful and discriminating analysis of some of the best pieces which our language contains, both in prose and verse, and if he strenuously endeavour to apply to them all the scientific principles which he has learned, there can be no doubt that he will acquire a manner of delivery, which will do ample justice to any subject on which he may be called to exercise his vocal powers.

Intimately connected with the subject of delivery is that of *Action.* Oratorical action has been defined to be the just and elegant adaptation of every part of the body to the nature and import of the subject on which we are speaking. As every man who feels his subject will necessarily have some action, it is of consequence that it should be graceful and significant. The first point to be attained is to avoid awkward habits, such as resting the chief weight of the body first on one foot and then on the other, swinging to and fro, jerking forward the upper part of the body on every emphatic word, keeping the elbows pinioned to the sides, and sawing the air with one hand with one unvaried and ungraceful motion. As for the attainment of excellences, more specific rules must be sought for in professed treatises on the subject, but the following general directions will be found to embrace much that is useful: "Keep the trunk of the body erect; let your hands be at liberty; feel your subject, and the action will come; recollecting at the same time that the right hand is essentially the instrument of action, and that the left should be used only as subordinate to it."

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[*] More properly *rhythmical cadences,* to distinguish them from the cadences of *melody.* Mr. Cull would prefer the term *measures.*

As gesture is used for the illustration and enforcement of language, so it should be limited in its application to such words and passages as admit of or require it. A judicious speaker will not only adapt the general style and manner of his action to the subject, the place, and the occasion, but even when he allows himself the greatest latitude, he will reserve his gesture, or at least the force and ornament of it, for those parts of his discourse for which he also reserves his boldest thoughts and his most brilliant expressions.

(On the subject of *action* very minute directions will be found in Austin's *Chironomia*; Chapman's *Music of the English Language*, Walker's *Elements of Elocution;* Richard Cull's *Acoustics and Logic in their Application to Reading aloud*, 1855; and James Hunt's *Manual of the Philosophy of Voice and Speech, especially in Relation to the English Language and the Art of Public Speaking*, 1859.)

ORB, ORBIT. The word *orbis* signifies the circumference of a circle or of any round body; *orbs* among the ancient astronomers meant the vast crystal spheres in which the heavenly bodies were supposed to be placed, and with which they revolved; hence orb came to be used for a sphere, as when the sun is called the *orb of day*. The word orbit now means the relative path [Motion] in which a planet travels round the sun, or a satellite round its primary.

We should perhaps rather say that by the orbit of a planet, technically speaking, is meant the approximate path, circular or elliptic, in which the planet may for a time be supposed to move without sensible error. Thus, when for some particular purpose, as the explanation of the seasons, we say the earth moves round the sun in a circle, we make an orbit which is exact enough for that purpose; and when, to explain the equation of time, we are obliged to have recourse to a more exact supposition, that of an elliptic motion, we are still said to speak of an orbit of the earth. But if we were to speak of the closely-folded interlacing spiral in which the centre of the earth actually moves round the sun, usage (and nothing else) would require us, if we would be understood, not to call this the orbit of the earth, but its real path, or real orbit, or some such distinctive term; for it is generally understood that the word orbit applies at most to the ellipse, which for a time does not differ sensibly from the real path. Theoretically speaking, this ellipse only touches the real path in one point; and the ellipse which most exactly tends to coincidence with the real path, consistently with satisfying other desirable conditions, is called the instantaneous ellipse. [Gravitation.]

The *elements* of the orbit are those quantities by which the position and magnitude of the (*pro tempore*) orbit are fixed, such as the major axis and eccentricity, which determine its magnitude; the longitude of the node and inclination of its plane to the ecliptic, which determine the position of that plane in space; and the longitude of the perihelion, which determines the direction of the major axis. One more determining quantity is tacitly supplied in the condition that one focus of the ellipse is always to be in the centre of the sun. The only remaining element is the periodic time of the planet, or its time of revolution round the sun; this however is not a separate element for each planet, but, all the other elements being given, is known for every planet when it is known for any one.

ORCEIN. [Lichens, *Colouring matters of;* Orcin.]

ORCHARD. Apples, pears, plums, and cherries are the fruits principally cultivated in orchards. The term orchard is likewise used to signify enclosures in which filberts or walnuts are grown: the word yard is commonly used for similar spaces appropriated to the production of figs and grapes.

Orchards of apples and pears are more numerous, because more productive, on the old and new red-sandstone formations than on any other strata; a very large proportion of all the cider and perry that is manufactured is grown upon these soils. The principal orchards of England are in Devonshire, Somersetshire, Gloucestershire, Herefordshire, and Worcestershire; on the continent, in Normandy and in the vale of Stuttgard; and in America, in the New England states.

For an orchard of apple-trees, a deep unctuous soil should be selected, in a situation sheltered from the north and north-west winds, and open to the south and south-east; and a bank is preferable to a low spot, for not only is the blossom more liable to be injured by spring frosts where fogs and damp prevail, but the trees themselves become mossy, and perish from excess of moisture. Dr. Lindley ('Guide to Orchard and Kitchen Garden,') recommends an early and effectual preparation of the soil, and the early transplanting of the trees. Young trees will require to be watered if a dry spring should succeed the autumn of their planting, and their roots should be occasionally dug round and manured. Pruning is advantageous to young trees when skilfully performed, for it is desirable that branches should not be crowded together, especially in the centre of the tree: we are of opinion that it is seldom beneficial to old trees, excepting for the removal of misletoe; and recommend that under no circumstances should a pruner be employed who amputates large limbs and leaves wounds which injure the alburnum or sap-wood by exposing it to the atmosphere, and produce canker in the stem or principal branches. It may frequently be useful in an exposed situation to plant two or three rows of pear-trees to shelter the apple-trees from the prevailing storms, as pear trees are on the whole less liable to suffer from wind than their more brittle kindred. The trampling of heavy cattle is at all times injurious to orchards.

For pear-orchards a lighter soil is desirable than for apples; the same rules may be observed for their planting and preservation. Washes for the destruction of the eggs of insects, and directions for the preservation of orchard-trees from barking by hares, rabbits, and sheep, are given in Lindley; Forsyth 'On Fruit Trees;' and Loudon's 'Arboretum.' For further information see articles Apple, Cider, and Pear.

The principal cherry-orchards in England are in Buckinghamshire and Kent; from the latter county a large supply is sent to the London markets. In Alsace, Würtemberg, Berne, and Basle, "kirschwasser," an ordinary spirit, is distilled from cherries. There are likewise orchards of a small acid cherry called "marasca" in the neighbourhood of Trieste, and also near Zara in Dalmatia, from which Maraschino is derived: in the Bergstrasse, near Heidelberg, there are cherry-orchards which furnish an early supply to the London market. The cherry and plum require but little pruning.

In all cases, as is judiciously pointed out by Mr. MacIntosh ('Book of the Garden,' vol. ii.) it is of great importance that good sorts should be introduced into, and the worthless extirpated from, our orchards as soon as possible. The importation of good foreign fruit has rendered the continued growth of inferior sorts a practice that must certainly result in loss. Much has been done in this direction by market gardeners.

For filbert and walnut orchards see Filbert and Walnut.

ORCHESTRA (Gr. ὀρχήστρα, which contains the same element as the verb ὀρχεῖσθαι, "to dance"), that part of the Greek theatre in which the chorus was situated—where the dances were performed. [Theatre.] With the moderns, the orchestra is the place in the theatre allotted to the instrumental band, and that portion of a concert-room which is assigned to the musical performers, both instrumental and vocal. We not only apply the word to the place set apart for the musicians, but often use it to designate the whole of them collectively; in which case, *orchestra* and *band* are treated as synonymous terms.

Till the end of the 17th century or the beginning of the 18th, the instrumental performers of our theatres were stationed in a box on the side of the stage, and out of view of the greater portion of the spectators. They were then few in number. But, however desirable in some respects, it would be impossible so to dispose of the large bands of the present day; and all things considered, they could not be better placed than where they now are—just below the stage, so as not to interrupt the sight, and between the singer and the audience, thus enabling the former to have in view the conductor and leader—a matter of great importance in the musical drama, where all is sung by memory.

The orchestra of a concert-room should be so contrived that the front, when no passage beneath it is required, is about five feet higher than the level of the room, and it should rise rather steeply to the back, the corners of which ought to be rounded off, in order that the whole body of sound may be directly reflected. But the due apportionment of the orchestra to the size and character of the room, and the requirements of the immense masses of vocal and instrumental performers now employed in the execution of oratorios, &c., is a matter that demands great knowledge of the laws of sound and considerable adaptive skill on the part of the architect. None of the great music halls yet constructed in this country can be considered as perfectly successful in this respect.

ORCHIL. [Lichens, *Colouring matters of.*]

ORCIN ($C_{14}H_8O_4 + 2Aq.$) *Alphaorcin.* It has already been stated [Lichens, *colouring matters of*] that this peculiar crystalline principle exists to a small extent in the free state in many of the lichens. It is largely produced, however, when lichens are exposed to the joint influence of heat and alkalies, conditions that always exist in the manufacture of *archil, litmus, cudbear* and other colour derivatives of the lichens. Under these circumstances, some acid substances that occur naturally in the lichens are split up into secondary acids and *orcin*, the latter immediately undergoing further alteration by absorbing oxygen and nitrogen, and becoming converted into a deep purple or red-coloured body termed *orcein*. By skilful management the operation may be arrested at any stage, various tints being thus obtained, or orcin itself may be extracted.

Stenhouse gives the following directions for isolating orcin: exhaust the lichens with water containing lime, boil the strained liquor till it is concentrated to about one-fourth its original bulk, separate lime by a current of carbonic acid, filter, evaporate to a syrupy consistence, treat with boiling absolute alcohol, and set aside to crystallise. The orcin thus obtained is usually of a red colour, but may be perfectly decolorised by two or three recrystallisations from ether.

Pure orcin crystallises in colourless quadrangular prisms, and is very soluble in water, alcohol, or ether. It is neutral to test paper, has a mawkish sweet taste, loses its two equivalents of water when moderately heated, or when exposed in vacuo, or even when crystallised from anhydrous ether. It sublimes in needles on being slowly heated in flat vessels; is precipitated white by acetate of lead, and red by perchloride of iron; is converted first into a resin, and finally into oxalic acid by nitric acid; and gives an intense purple-red colour, quickly changing to yellow, with chloride of lime.

Brom-orcin ($C_{14}H_5Br_3O_4$) was discovered by Stenhouse. It is formed on adding bromine to a concentrated aqueous solution of orcin, and may be obtained in silky needles by crystallisation from dilute alcohol. It is very fusible, insoluble in water, but soluble in alcohol or ether.

Chlor-orcin is produced in the same way, and much resembles brom-orcin. Its exact composition has not yet been ascertained.

In the presence of ammonia orcin rapidly absorbs oxygen, and is converted into *orcein* :—

$$\underbrace{C_{14}H_8O_4}_{\text{Orcin.}} + \underbrace{NH_3}_{\text{Ammonia.}} + \underbrace{O_6}_{\text{Oxygen.}} = \underbrace{C_{14}H_7NO_6}_{\text{Orcein.}} + \underbrace{4HO}_{\text{Water.}}$$

Orcin may be precipitated from its dilute ammoniacal solution by the addition of acetic acid; it then falls in red flocks, almost insoluble in water, readily so in alcohol and sparingly so in ether. It is very soluble in alkalies, forming rich purple solutions. Its solutions are decolorised by nascent hydrogen and again become coloured by exposure to air, but if ammonia is added before exposure, an abundant white precipitate of *leucorcein* is thrown down. Leucorcein becomes purple in contact with air.

Chlor-orcein is a yellowish-brown substance, formed on passing chlorine through water containing orcein. It is insoluble in water, but soluble in alcohol or ether.

ORDEAL, from the Anglo-Saxon *ordæl.* Spelman derives this word from *or*, "magnum," and *dæl*, "judicium," which is also the derivation given by Ducange. Lye and Bosworth derive it from *or*, privative, "without," and *dæl*, "difference," an indifferent or impartial judgment, a judgment without distinction of persons. The German word *urtheil*, a judgment, is apparently the same word, and is also a compound.

The earliest traces of any custom resembling the ordeal is found in the book of Numbers (ch. v.), in the waters of jealousy, which the Hebrew women suspected of adultery were compelled to drink as a test of their innocence.

Blackstone, speaking of the several methods of trial and conviction of offenders, says, "The most ancient species of trial was that by *ordeal*, which was peculiarly distinguished by the appellation of *judicium dei*; and sometimes *vulgaris purgatio*, to distinguish it from the canonical purgation, which was by the oath of the party. This was of two sorts, either fire-ordeal or water-ordeal; the former being confined to persons of higher rank, the latter to the common people. Both these might be performed by deputy; but the principal was to answer for the success of the trial, the deputy only venturing some corporal pain for hire, or perhaps for friendship. Fire-ordeal was performed either by taking up in the hands unhurt a piece of red-hot iron, of one, two, or three pounds weight, or else by walking barefoot and blindfold over nine red-hot ploughshares, laid lengthwise at unequal distances; and if the party escaped being hurt, he was adjudged innocent; but if it happened otherwise, as without collusion it usually did, he was then condemned as guilty. However, by this latter method Queen Emma, the mother of Edward the Confessor, is mentioned to have cleared her character when suspected of familiarity with Alwyn, bishop of Winchester. Water-ordeal was performed either by plunging the bare arm up to the elbow in boiling water, and escaping unhurt thereby, or by casting the person suspected into a river or pond of cold water, and if he floated therein without any action of swimming it was deemed an evidence of his guilt, but if he sunk he was acquitted." Another species of ordeal was the corsned, or morsel of execration: this was a piece of cheese or bread, about an ounce in weight, which was consecrated with a peculiar form, and it was prayed that the bread might cause convulsions and paleness, and find no passage, if the man was really guilty, but might turn to health and nourishment if he was innocent. The corsned was then given to the suspected person, who received the holy sacrament at the same time,—if, indeed, as some have suspected, the corsned was not the sacramental bread itself.

The Ordeals of water and iron are first mentioned in the 77th law of Ina; and afterwards in those of Athelstan, Edward the Confessor, and the Conqueror.

In 'Domesday' the readiness of claimants to prove their title to land, by ordeal or by battle, occurs in a great variety of instances: as among the lands belonging to the monastery of Ely, at a place then called Photestorp, in Norfolk: "Hanc terram calumpniatur esse liberam Vlchetel homo Hermeri quocunque modo judicetur, vel bello vel Juditio." (See tom. ii., fol. 213, and other instances, fol. 110 b, 137, 162, 166, 172 b, 193, 208, 277 b, 332.) 'Ferri candentis Judicium' (the ordeal of hot iron) is the only ordeal of the Domesday Survey.' The reason for this is given by Glanville (l. xiv., ch. 1): "in such a case the accused is bound to clear himself by the judgment of God, namely, by hot iron, or by water, according to the difference of rank, that is, by hot iron if he should be a free man, and by water if he should be a villein (si fuerit rusticus)."

Eadmer ('Hist. Novor.,' p. 48) speaks of no fewer than fifty persons of Saxon origin who, in the reign of William Rufus, being accused of killing the king's stags, were at one time sentenced to the fire-ordeal.

It is probable that the Trial by Ordeal was not discontinued in England by any positive law or ordinance, although Sir E. Coke (9 *Rep.*, 32), and after him Blackstone (4 *Comm.*, 345), have expressed an opinion that it was finally abolished by an act of parliament, or rather an order of the king in council, in the 3 Henry III. (1219). This order is to be found in Rymer's 'Fœdera,' vol. i., p. 228; Spelman's 'Glossary,' sub voce *Judicium Dei*; and in Selden's 'Notes to Eadmer.' Spelman, however, thinks that this was merely a temporary law, without any general or permanent operation, and that the Trial by Ordeal continued to a later period. This opinion seems confirmed by a reference in the 'Cal. Rot. Pat.,' p. 15, to another order in council in the 14 Henry III., 'De justitiâ faciendâ loco ignis et aquæ.' As, however, it is only mentioned as a former custom, and not as an existing institution, by Bracton (lib. iii., cap. 16), who wrote at the end of the reign of Henry III. or the commencement of that of Edward I., it is probable that, in consequence of the judgments of councils and the interference of the clergy, the Trial by Ordeal fell into disuse about the middle of the 13th century (Selden's 'Notes to Eadmer'); but this was long after it had disappeared from the judicial systems of most other European nations.

Blackstone, in the part of his 'Commentaries' already quoted, says, "Purgation by ordeal seems to have been very ancient, and very universal in the times of superstitious barbarity. It was known to the ancient Greeks: for in the 'Antigone' of Sophocles (v. 270) a person, suspected by Creon of a misdemeanor, declares himself ready 'to handle hot iron, and to walk over fire,' in order to manifest his innocence; which the scholiast tells us was then a very usual purgation." And Grotius (on 'Numb.' v., 17) gives us many instances of water-ordeal in Bithynia, Sardinia, and other places.

"In Siam, besides the usual methods of fire and water-ordeal, both parties are sometimes exposed to the fury of a tiger let loose for that purpose: and if the beast spares either, that person is accounted innocent; if neither, both are held to be guilty; but if he spares both, the trial is incomplete, and they proceed to a more certain criterion." ('Mod. Univ. Hist.,' vol. vii., p. 266.)

The 'Asiatic Researches' (vol. i., 4to. Calcutta, 1788, p. 389-404) contain a memoir on the trials by ordeal among the Hindus, by Ali Ibrahim Khán, chief magistrate at Benares, communicated by Warren Hastings, Esq., nine in number:—1, by the balance; 2, by fire; 3, by water; 4, by two sorts of poison; 5, by Cosha, in which the accused drinks of water in which the images of the sun and other deities have been washed; 6, by chewing rice; 7, by hot oil; 8, by hot iron; 9, by Dharmach, in which an image named Dharma, or the genius of justice, made of silver, and another of an antagonist genius Adharma, made of clay or iron, or those figures painted respectively on white and black cloth, are thrown into a large jar, from which the accused is instructed to draw at hazard.

The Latin forms of service for the different species of ordeal, as anciently used in England, are given by Spelman in his 'Glossary,' *in v.* from the Textus Roffensis.

The reader may consult for further information Grimm's 'Deutsche Rechts-Alterthümer, Gottesurtheil.'

ORDER is distinguished from *degree* in mathematical language by a purely conventional boundary. Both are terms of succession; thus an expression is of the first, second, third, &c., degree, according as its highest power is the first, second, third, &c., of the principal letter. But if another succession should occur, say one of differentiations, then the number of such successive operations is the order of the process. Thus a differential equation which contains, at the highest, the fifth power of a differential co-efficient, is said to be of the fifth degree; while if the highest differential co-efficient which occurs in it is the third, it is said to be of the third *order*.

There is a particular use of the word *order* in regard to quantities which increase or diminish without limit. If A and B both diminish without limit, but if A diminish without limit with respect to B [INFINITE], A is said to be of an inferior order to B; and generally the first powers of small quantities are said to be of the first order; products of two small quantities, and second powers, of the second order; and so on.

ORDER IN COUNCIL. [PRIVY COUNCIL.]

ORDERS, HOLY. [ORDINATION.]

ORDINARY. This term, when used in English law, commonly signifies the bishop of the diocese, who is in general, and of common right, the ordinary judge in ecclesiastical causes arising within his jurisdiction. (Lindwoode's 'Provinciale,' lib. i., tit. 3.) The term is also applied to the commissary or official of the bishop, and to other persons having, by custom or peculiar privilege, judicial power annexed to their offices or dignities. Thus an archdeacon is an ordinary. A bishop therefore is always an ordinary, but every ordinary is not a bishop.

The term is derived from the Canonists, and is in common use in several European countries. Since the Lateran council, when the apostolic see assumed the power of presenting to benefices, the pope has sometimes been called by canonical writers "ordinarius ordinariorum." The judex ordinarius of the canon and of the later Roman law is a judge who has judicial cognisance in his own proper right, as such judge, of all causes arising within the territorial limits of his jurisdiction. He is opposed to the judex delegatus, or extraordinarius, whose jurisdiction extends only to such causes as are specifically delegated to him by some superior authority. (Ayliffe's 'Parergon,' p. 309; Justin., 'Novell.,' 20, c. 3 and 112, c, 31.) With reference to this distinction, it became usual to apply the term "ordinary" to bishops, who, when acting in their judicial character in ecclesiastical causes, have strictly an ordinary jurisdiction; and we find it used in this sense by Bracton and the earliest writers upon English law.

ORDINATE is that particular rectangular Co-ordinate of a curve which is measured perpendicularly to one of the axes and not upon an axis. [CO-ORDINATE.] It is necessary to observe that though the term co-ordinate has been extended to what are called polar co-ordinates, yet the word ordinate is not separately used in the latter system. The etymology of ordinate will be found in the article cited.

ORDINATION, the ceremony by which holy orders are conferred, or by which a person is initiated into the ministry of religion, or set apart for preaching, administering the sacraments, and discharging other ecclesiastical rites and duties, public or private. In the Church of England, a candidate must be twenty-three years of age before he can be ordained deacon, and twenty-four before he can be ordained priest; must have an appointment to some cure, except he be a fellow of a college; bring letters testimonial of his life and doctrine, for three years, from three beneficed clergymen; undergo an examination in Latin, Greek, and theological learning; subscribe to the Thirty-nine Articles and the Liturgy; and, as bishops now almost invariably require, have graduated at one of the English universities, at Trinity College, Dublin, or at some other recognised school. No person can hold any vicarage, rectory, or benefice whatever, except he be in full orders.

A form of some kind has always been observed in conferring the priesthood. This was the case under the Old Testament dispensation; in which the family, age, and qualifications of the individual appointed, are particularly described. In the New Testament, our Lord called the twelve apostles, and sent them out—ordained them to perform the offices of religion. So likewise the apostles ordained others; and the form they adopted for setting them apart was *prayer* and the *imposition of hands*. In this manner bishops, priests, and deacons were appointed; and, for at least ten centuries, no other ceremony was used or added thereto. When the church became corrupt, this, like almost every other ordinance, shared the general perversion. It lost its primitive simplicity, and was elevated to the dignity of a sacrament. The plan was adopted of delivering to a person ordained priest the *sacred vessels*, that is, the plate and the cup; employing with the action certain words by which he was authorised to offer sacrifice to God, and to celebrate mass. To constitute a sacrament, three things are required, *matter*, *form*, and *institution*. Ordination was evidently instituted by Jesus Christ and his apostles; but in their institution of it, it clearly wants the main essentials of a sacrament. The church of the 11th century, in converting it into a sacrament, considered the *vessels* as the *matter*, and the *form* was the delivering them with the words:—"Take thou authority to offer up sacrifices to God, and to celebrate masses, both for the living and the dead; in the name of the Father, the Son, and the Holy Ghost." Protestant churches have returned to the original method of conferring orders, and use only prayer and the imposition of hands; some sects dispense with the latter, as the Wesleyan Methodists.

The great controversy between Episcopalians and Presbyterians is, the authority by which holy orders are conferred. The former hold that bishops alone are vested with this authority; and those especially who entertain the notion of *Apostolic succession*, that is, assert the fact of an unbroken episcopal series from the days of the Apostles to the present time, to which the power of ordaining ministers is confined and through which it descends, deny the validity of orders and even the existence of a church, where there is no bishop. The Presbyterians, on the contrary, contend that the presbytery, or a body of priests, have authority for this purpose; and that bishops and presbyters are in Scripture the same, and not distinct orders or officers. They urge that Timothy was ordained by the laying on of the hands of the presbytery; and that Paul and Barnabas were ordained by certain teachers and prophets in the church of Antioch, and not by any bishop presiding in that city. It is certain however that bishops have existed as a distinct order from the very earliest times; and though we cannot assert that they are absolutely essential, yet they evidently contribute to complete the idea of a church, and tend to its orderly and effectual operation.

Many at the Reformation held the call of the people the only thing essential to the validity of the ministry, and taught that ordination is only a ceremony which renders the call more solemn and authentic. Accordingly the Protestant churches of Scotland, France, Holland, Switzerland, &c., and the dissenting churches of England, have no episcopal ordination. For Luther, Calvin, Bucer, Melancthon, and all the first reformers and founders of these churches, who ordained ministers among them, were themselves presbyters and no other. There are some remarks on this subject, at once liberal and judicious, in Burnett's 'Exposition of the Thirty-nine Articles.'

ORDNANCE, a general term applied to the great artillery (guns, carronades, howitzers, and mortars) which is used in war, on land or at sea; the name being probably derived from the *compagnies d'ordonnance*, or France Archers, instituted in 1448 by Charles VII. of France.

The wars between the emperor Charles V. and Francis I. gave rise on the Continent to the first important improvements in the construction and use of heavy artillery. According to Templehof it was then that some efforts were made to establish a system of proportions between the length, the thickness, and the calibre of ordnance; that gunpowder was improved, and that certain relations between the charge of powder and the weight of the projectile began to be established. It was not, however, till the beginning of the 17th century that artillery, which had before been chiefly used in the attack and defence of fortresses, began to be extensively employed in engagements between hostile armies; but in 1632 the Austrians and Swedes together are said to have brought into the field 2000 pieces, among which were 24, 16, 12, and 6 pounder guns.

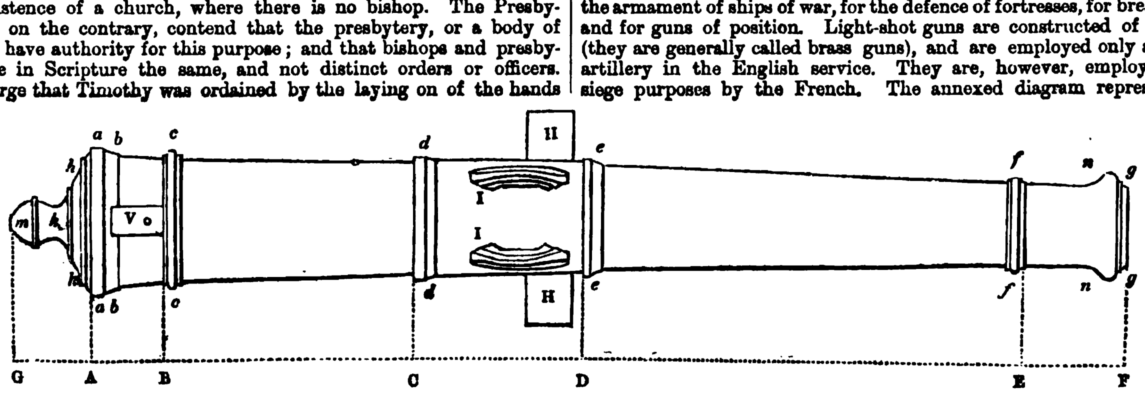
An artillery capable of accompanying the rapid movements of cavalry, was first systemically introduced into warfare by Frederic the Great [ARTILLERY]; but the full development of the important services which are capable of being rendered by this arm is due to the Prussian general Scharnhost, since whose time the horse-artillery, as it is called, has been considered as an indispensable requisite in the armies of every nation in Europe.

In the British service a rocket carriage and tube for the military rockets invented by Sir W. Congreve, is attached to each troop of horse artillery and battery of artillery; and these missiles, which have been employed under various circumstances, have occasionally rendered considerable service. [ROCKET.]

The construction or mode of manufacture of artillery has been described under CANNON. Under the present head we propose to describe generally the size, &c., of the guns now in use in the service, and very briefly their uses. Rifled ordnance, which are now being adopted in the service, will be found described under RIFLE.

Under the general term ordnance there were comprised guns of five classes: shot guns, shell guns, howitzers, carronades, mortars; to these may now be added the rifled ordnance, shot and shell guns.

Shot guns of the ordinary smooth-bored construction are comparatively long and heavy, being employed for projecting solid shot on all occasions when considerable penetration or length of range is requisite; they are of course, however, capable of throwing shells and all other descriptions of ammunition. The calibre of a shot gun is denoted by the weight of a cast-iron spherical shot, of which the diameter is the same with the bore of the gun. The heavy-shot guns are constructed of cast-iron, and are used for sea-coast batteries, for the armament of ships of war, for the defence of fortresses, for breaching, and for guns of position. Light-shot guns are constructed of bronze (they are generally called brass guns), and are employed only as field artillery in the English service. They are, however, employed for siege purposes by the French. The annexed diagram represents a



AF is considered as the length of the gun (= 7 feet); AB is called the vent-field (= 5·5 in.); V, the vent; BC, the first reinforce (= 20·9 in.); CD, the second reinforce (= 13·3 in.); DE, the chase (= 35·8 in.); EF, the muzzle (= 8·5 in.); AG, the cascable (= 6·2 in.); HH, the trunnions; II, the dolphins or handles; *aa* is called the base ring (diam. = 11·75 in.); *bb*, the base ring ogee; *cc*, an astragal and fillets; *dd*, the first reinforce ring and ogee (diam. = 9·8 in.); *ee*, the second do. (diam. = 9·5 in.); *ff*, an astragal and fillets (diam. at *nn* = 6·83in.); *gg*, the muzzle mouldings; *hh*, the breech ogee and fillets; *k*, the neck; *m*, the button.

brass gun (a heavy six-pounder). Shell guns differ from shot guns in being of greater calibre in proportion to their weight of metal. The bore of shell guns is also contracted towards the breech, thus forming a chamber. The size of shell guns is denoted by the diameter of the bore in inches. Shell guns are employed for projecting shell and hollow shot, and are principally for sea service. They are made of iron. Guns of 12-inch diameter have been made, but the sizes employed in the service now are the 10-inch and 8-inch guns only.

We have subjoined a table of the dimensions and weights of the principal natures of guns in use in the British service. The natures and uses of carronades, howitzers, and mortars have been already described under those words.

Construction of Ordnance—Iron.

Service.	Construction.	Nature of Ordnance.	Length. ft.	Length. in.	Weight. cwt.	Calibre. inch.
S	M	10-inch gun	9	4	86	10
S	M	68-pounder gun	10	10	113	8·12
S	M	68 „	10	0	95	8·12
S	M	68 „	9	6	87	8·12
S L	M	8-inch gun	9	0	65	8·05
S	M	8 „	8	10	60	8·05
S	M	8 „	8	0	52	8·05
L	M	8 „	6	8½	50	8·05
L S	M′	56-pounder gun	11	0	98	7·65
L	M′	56 „	10	0	85	7·65
S	M	42 „	10	0	84	6·97
S	M	42 „	10	0	75	6·97
S	O	42 „	9	6	67	6·935
S	M	32 „	9	7	64	6·41
S	O	32 „	9	6	56	6·41
S	O	32 „ (a bored up 24) .	9	0	46	6·41
S	O	32 „	8	0	48–50	6·41
S	M′	32 „ (Monk's A) . .	9	0	50	6·375
S	M′	32 „ (Monk's B) . .	8	6	45	6·35
S	M′	32 „ (Monk's C) . .	8	0	42	6·35
L	I	32 „ (a bored up 18) .	8	0	41	6·35
L	I	32 „ (a bored up 24) .	7	6	40	6·35
L	I	32 „ (a bored up 24) .	7	6	39	6·35
L	I	32 „ (a bored up 24) .	6	6	32	6·3
L	I	32 „ (a bored up 18) .	6	0	25	6·3
L	M	32 „	5	4	25	6·3
L	O	24 „	9	6	50	5·823
L	O	24 „	9	0	48	5·823
L	I	24 „ (a bored up 18) .	8	0	37	5·823
L	M	24 „	7	6	41	5·792
L	M	24 „	6	6	33	5·792
L	O	24 „ (a bored up 12) .	6	0	20	5·75
L	O	18 „	9	0	42	5·292
L	O	18 „	8	0	38	5·292
L	I	18 „ (a bored up 9) .	7	0	22	5·174
L	I	18 „ (a bored up 12) .	6	0	20	5·174
L	I	18 „ (a bored up 9) .	5	6	15	5·174
L	O	12 „	9	0	34	4·62
L	O	12 „	8	0	33	4·62
L	O	12 „	7	6	29½	4·62
L	O	12 „	6	0	27	4·62
L	O	9 „	8	6	28½	4·2
L	O	9 „	7	6	26	4·2
L	O	9 „	7	0	25	4·2
L	O	9 „	5	6	17	4·2
L	O	6 „	8	6	23	3·66
L	O	6 „	8	0	22	3·66
L	O	6 „	7	6	21	3·66
L	O	6 „	7	0	20	3·66
L	O	6 „	6	6	18	3.66
L	O	6 „	6	0	17	3·66
L	O	6 „	5	11	11	3·66
S	O	32-pounder carronade . . .	3	11¾	17	6·25
S	O	24 „ „ . . .	3	7⅖	13	5·58
S	O	18 „ „ . . .	3	9¼	10	5·16
S	O	12 „ „ . . .	2	8½	6¾	4·52
L	M	10-inch howitzer . . .	5	0	43	10
L	M	8 „	4	0	22	8
L	O	5½ „	3	4¾	15	5·68
S	O	13-inch mortar	4	4	100	13
L	O	13 „	3	3½	36	13
S	O	10 „	3	9	50	10
L	O	10 „	2	7½	18	10
L	O	8 „	2	1¼	9	8

S, Sea service; L, Land service; S L, both; M, Millar; M′, Monk; O, Ordinary; I, Intermediate between M and O, being bored-up guns.

The axis of the trunnions is at right angles to that of the gun, and is usually about half their diameter below the latter axis; but Dr. Gregory, in his 'Lectures on Gunnery,' recommends that it should intersect the axis of the gun, in order that the recoil of the piece in firing may act less on the carriage. The vent is two-ninths of an inch in diameter, and it enters the bore at about eight-tenths of an inch from the bottom of the latter.

Construction of Ordnance—Brass.

Service.	Construction.	Nature of Ordnance.	Length. ft.	Length. in.	Weight. cwt.	Calibre. inch.
L	O	12-pounder gun (medium) . .	6	6	17¾	4·623
L	O	9 „	5	11	13½	4·2
S L	O	6 „ (long) . . .	7	0	12	3·66
L	O	6 „ (light) . .	5	0	6	3·66
L	O	3 „ (long) . . .	6	0½	6	2·91
L	O	3 „ (light) . .	4	0	3	2·91
L	O	3 „ (colonial) . .	4	0	3	2·95
L	O	3 „ (mountain) .	3	0	2¼	2·91
L	O	1 „ (mountain) . .	5	0	2½	2·01
L	M	32-pounder howitzer (Dundas) .	5	3	17½	6·3
S L	M	24 „ „ . . .	4	8½	12	5·72
L	M	12 „ „	3	9	6½	4·52
L	O	4⅖ „ „ (light) .	1	10¾	2¼	4·52
L	O	4⅖ „ „ (Coehorn) .	1	10¾	2¾	4·52
L	O	5½-inch mortar (royal) . .	1	2¾	1¼	5·62
L	O	4⅖ „ (Coehorn) . .	1	0⅝	1	4·52

S, Sea service; L. Land service; S L, both; M, Millar; M′, Monk; O, Ordinary.

The diameter of the bore is called the calibre of the gun; this is rather greater than the diameter of the shot by which the nature of the gun is designated, and the difference between them is called the windage. [Windage.]

A scale of quarter degrees is graduated on the base ring, the zero line being in a plane passing through the axis of the gun and cutting the exterior surface immediately above the trunnions, and the intersection of such plane with the side of the muzzle is marked by a notch on the latter. These quarter-sights, as they are called, serve to give the gun an elevation not exceeding three degrees; and this is accomplished by lowering the breech till the division expressing the intended elevation and the notch on the side of the muzzle are in a line with the object. The axis of the gun will then be inclined to a plane passing through the object and the axis of the trunnions, in an angle equal to that which is indicated by the division above mentioned.

A point-blank disposition of the gun is that in which the zero notch on the base ring and that on the side of the muzzle are made to coincide in direction with the object, whether this line of direction be or be not parallel to the horizon. But when a notch on the top of the base ring and one at the top of the muzzle are made to coincide in direction with the object, the gun is said to have the *line of metal elevation*. [Gunnery.] The angle which the axis of the gun, in this case, makes with a plane passing through the trunnions, and the object, varies with the nature and construction of the gun, but is generally about one degree.

For elevations greater than three degrees a tangent scale is employed; this is a brass rod which slides up and down in a groove formed in the direction of a diameter to the base-ring of the gun, and is divided into quarter degrees. In using this scale the latter is drawn up till the graduation expressing the intended elevation is at the surface of the base-ring; then the breech of the gun is lowered till a notch at the top of the scale and that at the top of the muzzle are in a line with the object. The axis of the gun (allowance being made for the difference between the semidiameters of the base-ring and muzzle [Dispart]) is then inclined to a plane passing through the trunnions and the object in an angle indicated by the said graduation.

It was considered advisable at one time to convert a number of heavy guns into a description of shell gun by boring or *reaming up*, that is, re-boring and enlarging the bore of various guns in the service to the next higher calibre: thus, 24-pounders were bored up into 32-pounders. The practice was first recommended by Colonel Paixhans, in France.

The application of locks to naval ordnance was introduced by Sir Charles Douglas (captain of the fleet to Admiral Rodney in the action of 1782), and their efficiency was soon fully recognised. At first the locks were made with one flint only, and in the event of this becoming unserviceable the loss of time attending the fixing a fresh flint was found to be so great, that instead of renewing the flint, recourse was generally then had to the lintstock or port-fire. But this defect was removed by the construction of a lock which carried two flints, so disposed, that on the failure of one, by simply turning the nut, the other might be brought into use. This improvement was made in 1818, by Major-General Sir Howard Douglas; it was immediately introduced in the British navy, and was afterwards adopted in the land-service artillery. This was followed soon afterwards by the introduction of the percussion tube into the navy and heavy artillery, and the friction tube for field artillery, and indeed for heavy artillery also often when on shore. The percussion tube is fired by a hammer which is made to strike simply by a pull on a lanyard attached to it. It is so contrived that after striking it is withdrawn from the vent and therefore not thrown back by the explosion of the powder. The friction tube is fired by sharply pulling out a portion of the head which projects above the vent, and which is made with an eye for the insertion of the hook of the lanyard.

From experiments made in France it was ascertained that hollow shot, being with equal weight greater in diameter than such as are solid, when fired with low charges of powder against ships, produced most dangerous breaches in their sides; and, in consequence, certain heavy iron howitzer-guns for discharging such missiles were introduced in the French navy. Similar experiments, attended by like results, were in 1828 made in this country by the late General Millar, with a short and massive 12-inch gun which he invented on the occasion. The hollow shot projected from this piece of ordnance weighed 120 pounds, and being impelled by 11 pounds of powder, producing an initial velocity of 1000 feet per second, it pierced, at the distance of 400 yards, a strong frame-work of timber, making an opening which would have seriously compromised any ship so struck. A conviction of the necessity of using these powerful arms in a future war led the British government to adopt 8- and 10-inch guns in the royal navy, and now the ships of war always carry a certain number of such guns.

Various experiments were made in France, England, and America, on the effect of shells fired into and exploded in ships, the fuses being cut of such a length as to explode the shell after striking; or, still better, by means of concussion fuses. The destructive effects were so great that shells and shell guns were at once adopted in the navy, and form a large portion of the armament, though the existence of loaded shells on board of ships has been objected to on account of the danger which might ensue from the accidental ignition of their fuses. This danger, however, may be much lessened by keeping each shell in a separate box, and by covering the fuse with a metallic cap till the moment when it is required to be put in the gun.

The carriages for guns vary much according to the calibre of the gun and the objects to which they are to be applied, or the mobility required.

The field gun carriage, in which great lightness and mobility combined with strength are required, is composed of one large solid piece termed the trail, to which two small brackets are attached, one on each side. The trail rests at one end on the axletree of a pair of high wheels. The trunnion holes are cut in these brackets: as it is necessary to come into action very rapidly there is only one set of trunnion holes in a field gun carriage, and they are placed far back on the carriage over the rear of the axletree, which has been found to be the best position both on account of the reduced strain on the carriage when fired, and of the ease with which the trail can be lifted to limber up or unlimber the gun. When the gun is in action the rear extremity of the trail rests on the ground, but when it is required to be moved, the end of the trail which is fitted with an eye is raised and placed on a hook in the limber.

The limber is a bed, with shafts, mounted on two wheels, and carrying two ammunition boxes for the service of the gun; the horses are harnessed to the limber, and the gun with its carriage is drawn after the latter. An ammunition waggon also accompanies each piece of ordnance, and there are others always in reserve.

Field howitzer carriages and their limbers are similar to those just mentioned, but stronger.

Carriages of a light construction are employed for the small artillery which is used on service in mountainous countries.

The travelling carriages for siege-ordnance are made wholly of oak, and the limber carries no ammunition; the great size and weight of the gun-carriage trail not permitting, when it rests on the limber, the boxes to be placed there. The trail of siege-carriages is made of two cheeks or side pieces firmly attached together by means of transoms, and resting on the axletree of the wheels, instead of in a single piece or block trail, as with field gun-carriages.

Carriages for garrison service and for the navy consist of two short cheeks or brackets, connected by transoms, and they move on four truck-wheels. Garrison carriages are now often made of cast-iron, which is more durable than wood, particularly in tropical climates. High platforms of timber or cast-iron are also occasionally placed at the salient angles of fortresses; they are made to turn at one extremity upon a vertical pivot, the other extremity traversing through ninety or a greater number of degrees. The usual garrison carriage is mounted upon this platform, and thus the piece can be fired over the parapet in any direction at pleasure. There is also a species of mounting for guns, termed a traversing platform, by means of which the gun may be made to pivot on any centre, and be directed with great ease in various directions. Traversing platforms are principally used for heavy guns, 68-pounders, and 8- and 10-inch guns on board ships and in casemates.

Mortars are placed upon solid beds of wood or iron, which are made as heavy as is consistent with the power of transporting them from place to place, and for the sake of obtaining steadiness when the piece is fired. The larger kinds of mortars and their beds are removed on platform carriages. Sea mortar-beds are made of strong timber; they have a hole in the middle for receiving the iron bolt on which the bed turns round, and they are placed on strong wooden frames fixed in the vessels by which they are carried.

The number of horses employed in the British service to draw artillery of the different natures is as follows:—For an 18-pounder or an 8-inch howitzer, from 8 to 10 horses. For a 12-pounder, 9-pounder, a heavy 6-pounder, or a 24-pounder howitzer, from 6 to 8 horses. For a light 6-pounder, a heavy 3-pounder, or a 12-pounder howitzer, from 4 to 6 horses. It may be observed here, that 4 horses cannot draw a weight twice as great as that which can be drawn by 2; therefore the number of horses which should be applied to draw weights must be increased in a higher ratio than the weights.

Formerly two 6-pounder guns were attached to each battalion of infantry, but this practice has long been discontinued, and now all the artillery which accompanies an army into the field is formed into batteries or brigades, each invariably consisting of six pieces. The brigades of foot-artillery consist either of five medium 12-pounders and a 32-pounder howitzer, or five 9-pounders and a 24-pounder howitzer; and a troop of horse-artillery is usually composed of five 9-pounders, 24-pounder howitzer, though they have occasionally been composed of 6-pounders and 12-pounder howitzers.

Six-pounder guns were not much employed with the armies under the Duke of Wellington, as they were found to be inferior in effect to the artillery which the French brought into action during the war; they may, however, be advantageously employed with a corps detached for the purpose of intercepting an enemy's convoy; but it may be observed in general, that field ordnance should be such as may take good effect against troops at the distance of 800 or 1000 yards: 12-pounders, and even 18-pounders, are necessary in the field when it is required to destroy palisades or small intrenchments, to break down bridges, and the like.

The guns hitherto employed in siege trains have been 18- and 24-pounders, and 8- and 10-inch howitzers, though at the siege of Sebastopol 32- and 68-pounders and 8- and 10-inch guns were employed. The mortars are the 8- and 10-inch, and occasionally, as at Sebastopol, the 13-inch mortar and the small Coehorn or 4⅖-inch mortar.

With respect to the quantity of ordnance which should accompany an army into the field, no precise rule can be given, as the ratio of the number of men to that of the guns in the great armies on foot during the wars of the early part of the century was very various; but, according to General Lespinasse, a division of 12,000 men, including two regiments of cavalry, should be attended by three brigades of horse and three of field artillery: one brigade of each kind is recommended to be always with the division, another of each kind to remain with the general *park* of artillery, and the rest with the depôt in rear of the army.

Long guns have now wholly superseded carronades for the navy, both because their fire is more accurate, and because of their greater range and penetration. For the sake of obtaining a nearly horizontal direction when a ship is rolling, it is a common rule in action to fire when the vessel is nearly upright; but this is said to be subject to some limitation, for it may happen that then the ship is in the trough or hollow of the sea, in which case she will have less command over her enemy than if she were on the summit of a wave: and it is recommended that shot intended to take effect on the hull of an enemy's ship should be discharged while the side engaged is descending towards the water; or if intended to act against the rigging, it should be fired with the rising motion of the side, provided the aim be taken low.

For further information on the subject the reader is referred to Sir H. Douglas's 'Treatise on Naval Gunnery.'

ORE. [MINING.]

OREADES ('Ορειάδες, from 'Ορος, a mountain), Nymphs who dwelt in mountains, caves, and grottoes; but the nymph of each cave and mountain had a specific name corresponding to that of her dwelling-place. (Pausanias, v. 5, ix. 3, and x. 32; see also Theocritus, 'Id.,' vii. 137.) The Oreades were among the attendants on Artemis. The most celebrated of the Oreades was Echo, who incurred the anger of Hera by engaging her in talk on the mountains whilst Zeus sported with others of the Nymphs. On discovering the trick, Hera deprived her of control over her tongue, so that she became unable to speak till some one else had spoken, and then unable to keep from repeating what was said. Wandering thus, she met and became deeply enamoured of Narcissus, who not requiting her affection, she pined away until nothing remained of her but her voice. (Ovid, Met. iii.)

Under NAIADS and NEREIDS we have spoken of the Nymphs of the fountains and fresh waters and of the sea: we here add a brief account of Nymphs generally, in order to render our notice of the subject more complete.

Nymphs (Νύμφαι, *Nymphæ*) were female deities in the Greek and Roman mythology, who were exceedingly numerous, and were supposed to preside over all parts of the earth. Those who presided over rivers, brooks, and springs, were called *Naiads*; those over mountains, *Oreades*; those over woods and trees, *Dryades* and *Hamadryades*; those over the sea, *Nereids*; those over valleys, *Napææ*, &c. (Homer, 'Il.,' xx. 8.) They were thus associated with all the forms of external nature; and they were the attendants of Hera, Aphrodite, Artemis, and other of the higher goddesses; they are also seen with Apollo; as the nurses of many of the gods, as Zeus, Dionysus, and Pan;

and along with Dionysus, Pan, and the Satyrs in their dances and revels. Their lives were very long, but they were not immortal. (Paus., x. 31, sec. 2.) They were worshipped in many parts of Greece, and were propitiated by offerings of milk, oil, and honey, and by sacrifices of lambs (Theocr., 'Id.,' v. 53, 149); and temples were also dedicated to them in Italy. (Cic., 'De Nat. Deor.,' iii., 17.) Another class of Nymphs were regarded as the personification of, or as in some way associated with, particular races and localities, as Cyrene, the Dedonides, Nysiades, &c. The Nymphs occur very frequently in ancient art either alone, as attendants on one or other of the superior deities, or in Bacchic dances: they are represented as lovely but somewhat impassive maidens, generally clad in light transparent garments, or partly undraped. We give a cut of a very beautiful statue of one, an attendant on Artemis, now in the Third Græco-Roman Saloon of the British Museum; it was found in 1766, in the Villa Verospi, near the Salarian Gate, Rome.

ORELLIN. A yellow colouring matter found in the seeds of the *Bixa orellana*. It is soluble in water and alcohol, and dyes yellow with an aluminous mordant.

ORGAN (*Ὄργανον*, Gr., *órganum*, Lat., an instrument), the noblest of musical instruments, whether considered in regard to the grandeur and beauty of its sounds, the variety of its powers, or the sacred purposes to which it is usually dedicated. It consists of a vast number of metallic and wooden pipes, divided into different *stops*, the wind being admitted into the pipes from a bellows, and is played on by means of a key-board. The machinery of an organ, which is rather complicated and exceedingly curious, is described in the next article.

Originally the word *organum* had a very extensive meaning, and signified nearly every kind of instrument, for whatever purpose employed. By degrees it was confined to instruments of music; afterwards it was applied only to those of the pneumatic or wind kind; and finally it was exclusively used to designate that "world of sounds" which we call the organ. It can hardly be doubted that this instrument may be traced to *Pan's-pipes*, or the *syrinx*. It must soon have been discovered that the air may be forced into a closed cavity, and then distributed at will to one or more tubes; and, pursuing the contrivance a little further, something like a modern organ was likely to be produced. Indeed, Mersenne, in his 'Harmonie Universelle,' mentions an ancient monument in the Mattei Gardens in Rome, on which appears the representation of a pneumatic organ. It is a small chest placed on a table. In the front is a female figure playing on a number of keys, and on the other side is a man blowing into the box with a pair of bellows exactly like those in present use. In Hawkins's 'History of Music' (i. 403) is an engraving of this, from a copy found among the papers of Haym, the author of a history of ancient medals. St. Augustine, in his Comments on the 56th Psalm, alludes to instruments inflated by bellows. In the same passage he also gives us to understand that *organ* was a generic term, including every species. "Organa," he says, "dicuntur omnia instrumenta musicorum," &c.

The descriptions left us by different authors of the musical instruments of the early part of the middle ages, and the representations of them on several monuments, prove that attempts were made at different periods to improve them. Much thought was expended in discovering the best method of introducing air into the pipes of the organ. For this purpose a fall of water was employed, and also what must be understood to have been steam. William of Malmesbury describes the manner in which the latter was used. He says, "The wind, being forced out by the violence of the hot water, fills the whole cavity of the instrument, which, from several apertures, passing through brass pipes, sends forth musical noises." At length bellows were employed for the purpose, which were either worked by water or by hand. The application of these two powers led to the distinguishing terms *hydraulic* and *pneumatic*, or water-organ and wind-organ, though, in point of fact, the ultimate result was the same in both. The invention of the former, which historians call an *hydraulicon*, is ascribed to Ctesibius of Alexandria, who lived about B.C. 150–120. [CTESIBIUS, in BIOG. DIV.] Vitruvius is the first writer who gives any account of an organ of that kind.

The period when the organ was introduced into the churches of Western Europe is very uncertain. Pope Vitalian is supposed to have been the first to admit the instrument, about the year 670; but the earliest account to be at all relied on of the introduction of the instrument in the West is, that about the year 755 the Greek emperor Copronymus sent one as a present to Pepin, king of France. In the time of Charlemagne, however, organs became common in Europe. That prince had one built at Aix-la-Chapelle, in 812, on a Greek model, which the learned Benedictine, Bedos de Celles, in his vast but useful and excellent work, 'L'Art du Facteur des Orgues' (1766),* considers to have been the first that was furnished with bellows without the use of water.

Before the 10th century organs were not only common in England, but exceeded both in size and compass those of the Continent. St. Dunstan gave one to the abbey of Malmsbury, in the reign of Edgar, Elfeg, bishop of Winchester, obtained one for his cathedral in 951, which was the largest then known. This is described in eight Latin verses by Wolstan, the learned monk of Winchester, in the 10th century, of which Mason, the poet, in his 'Essay on Instrumental Church Music,' gives the following translation:—

> "Twelve pair of bellows, rang'd in stated row,
> Are joined above, and fourteen more below.
> These the full force of seventy men require,
> Who ceaseless toil, and plenteously perspire;
> Each aiding each, till all the wind be prest
> In the close confines of th' incumbent chest,
> On which four hundred pipes in order rise,
> To bellow forth that blast the chest supplies."

The translator adds an explanation by no means unnecessary. "We are not," he says, "I think, to imagine that these stout bellows-blowers kept their bellows in action all the time the organist was playing. I rather think that his performance did not commence till they had filled the chest completely with wind, which he was afterwards to expend by due degrees, as he found occasion."

The organ was at first very rude in its construction, and extremely limited in its means. The keys were four or five inches broad, and must have been struck by the clenched hand, in the manner of the carillons. The pipes were of brass, harsh in sound, and the compass in the 12th century did not exceed a dozen or fifteen notes, and to accompany the plain chant no more were required. About that time half-notes were introduced at Venice, where also the important addition of pedals, or foot-keys, was first made in 1470, by Bernhard, a German, to whose countrymen we owe many improvements of the instrument, though in excellence of finish they have been surpassed by our English builders.

Few particulars are recorded concerning the organs of this country from the Reformation to the time of Charles I. Camden mentions one at Wrexham, and Fuller has been strangely misguided in describing it to have had pipes of gold. It shared the general fate of organs in 1641; and the old York organ, replaced some years back by a new instrument, was one of the very few that escaped the *organoclasts* of those times. At the Restoration it appeared that only four organ-builders of eminence survived, a circumstance which led to the introduction of foreign artists,—of Bernard Schmidt (commonly called *Father Smith*), and his two nephews, with the elder Harris, and his son Renatus. An account of the dispute between those two family parties is amusingly related in Burney's 'Hist.,' ii. 437. Each erected an organ in the Temple Church, as a trial of ability: Blow and Purcell displayed Smith's, and Mons. Lully (not the great composer) that of the Harrises. The Lord Chancellor Jeffries at length decided in favour of Smith. The principal organs of the latter are—the Temple; Christ-church and St. Mary's, Oxford; Trinity College, Cambridge; St. Margaret's, Westminster; St. Clement's Danes; Southwell Minster; Trinity Church, Hull; and St. Paul's Cathedral. Harris's organ, after being rejected by the Templars, was divided; part was erected in St. Andrew's, Holborn, and part in Christ-church, Dublin. This last portion was afterwards removed to Wolverhampton. His other principal instruments are those at St. Mary-Axe, St. Bride's, St. Lawrence (Cheapside), and Doncaster. He, however, from some unexplained cause, was commissioned to make twice as many organs as his competitor. The 'Spectator,' No. 552, says that he was ambitious of building an organ for the metropolitan cathedral. We have, however, no reason to regret that his wish was not gratified.

To these celebrated mechanicians succeeded Schreider, Smith's son-in-law, who built the organ in Westminster Abbey, and that at St. Martin's-in-the-Fields, the latter a present from George I. as churchwarden; Snetzler, Byfield, &c.; and at a later period, Green, Avery (who most successfully imitated Smith); Gray, Elliot, &c.

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* A copious work on the Organ by M. Hamel, chiefly compiled from that of Celles, has been published in the 'Encyclopédie Roret.' It is in three small volumes, together with an Atlas, containing nearly 1000 figures.

The tone of the pipes of the old builders—depending on what is technically called the *voicing*—has never been excelled by later makers; but in point of *touch*, and mechanism generally, the moderns are much superior to their predecessors. In mechanical skill and delicate finishing the English organ-builders far surpass their Continental rivals, while in tone they at least equal them; but the costliness of our materials and high rate of wages render the organs of this country much more expensive than those of Germany and France. It has been truly observed, that "notwithstanding the imposing enumeration of so many stops, the large organs of the Continent are inferior in the choice and variety of them to the best English instruments;" a part being, in fact, but half-stops, and several only absurd imitations of other musical instruments, and rarely, if ever, used by scientific organists.

The following is a list of some of the largest and most celebrated foreign organs, from Crosse's 'Account of the York Festival,' 1823, "collected," he says, "from many sources, and enriched with some additions communicated by the Rev. C. I. Latrobe":—

	Stops.	Pipes.
Seville cathedral	100	5300
Goerlitz, in Upper Lusatia	82	3270
Hamburg, St. Michael's	67	
(9 pipes of 16 feet, and 3 of 32)		
Amsterdam, the old chnrch	64	
Weingarten, a Benedictine monastery in Suabia	60	6666
(7 pipes are of 16 feet, and 3 of 32)		
Tours cathedral	60	
Haarlem	60	5000 nearly,
(8 of these pipes are 16 feet, and 2 of 32; the greatest diameter being 15 inches. It is 108 feet high, and 50 broad.)		
Alost	58	
Berlin, St. Peter's	50	
Vienna, St. Michael's	40	
Rome, St. John Lateran	36	
Baltimore, in America	36	2213

Mr. (afterwards Sir John) Barrow, in his 'Tour' (1830), mentions a new organ erected in the church of St. Lawreuce, in Rotterdam, containing 5500 pipes, which, according to his calculation, is 150 feet in height.

Our English church-organs are numerous, and generally well toned. Though we have none containing so many nominal stops as a few on the Continent can boast, yet we possess some which, in regard to the greater calibre of the pipes, and power of every kind, surpass any foreign instrument. Chief among these are the new organ in York Minster, and that in the town-hall of Birmingham.

The York organ, built by Elliot and Hill, which has lately been enlarged and improved, contained 56 stops all through, besides 6 copula stops. The number of pipes was 4200. The largest metal pipe was 32 feet in length and 20 inches in diameter; the largest wooden pipe was 27 feet long, 3 wide, and 2¼ deep. This, the builder boasted, would contain 12 pipes and 2 gallons of wine. Both pipes gave C, three octaves below the second space in the base. It had three rows of keys, and two octaves and one-third of pedals. The width of this instrument was 70 feet, and its height in proportion. The old York organ, burnt in 1829, was the largest in the kingdom; it had 3254 pipes distributed among 52 stops.

The Birmingham organ, built by Hill, and completed in 1836, is, as regards size and power, the rival of that at York, though the latter is superior in both, but not in quality. This is 35 feet wide, 15 deep, and 45 high. The swell-box alone is the size of a moderately large church-organ. It has 40 real stops, about 3000 pipes, 4 rows of keys, and 2 octaves and one-third of pedals. The largest metal pipe is 35 feet long, and 21 inches in diameter, formed, as all the metal pipes in this instrument are, of zinc only. The weight of the whole is about 40 tons.

The old organ in St. Paul's cathedral contains 1797 pipes, divided into 28 stops; 3 rows of keys, 2 octaves of pedals, and the largest pipe is 22 inches in diameter. That in Westminster Abbey has 28 stops, and 1524 pipes; 3 rows of keys, and double diapasons for the pedals. At Exeter is an organ, built by John Loosemore, in 1666; its largest pipes are 15 inches in diameter. The organ at Lynn, made by Snetzler, has 30 stops, and among them is a *dulciana*, there first introduced. Green built the organs at Canterbury, Windsor, Lichfield, and Salisbury. That in King's-College chapel, Cambridge, was built by Avery. The organ at Yarmouth, erected in 1740, has 29 stops. St. Peter's, at Leeds, contains the same number, with 3 rows of keys, built by Messrs. Greenwood, of that place. The new church of St. Luke, Chelsea, has been provided with an organ, made by Nicholls, containing 33 stops and 1876 pipes. The organ of St. Sepulchre, London, contains 2500 pipes, divided into 40 stops; and that at Christ's Hospital, by Hill, is equal in number of pipes and power to any in the metropolis. The large organ in St. Patrick's, Dublin, was presented to that cathedral by Queen Elizabeth.

The Great Exhibition of 1851 contained some fine organs, but such was the vastness of the enclosure that they produced very little effect, except in their immediate vicinity. One of these organs (by Willis), altered and enlarged, went afterwards to Liverpool. Another large organ, by Hill, was exhibited at the Panopticon in Leicester Square, but on the breaking up of that establishment it was transferred to St. Paul's Cathedral, London, to meet the altered circumstances under which divine service is now at certain periods conducted in the nave of that building. The organ recently built for Ely Cathedral is a fine instrument. It would, however, be quite impossible, within moderate limits, to do justice, even by a bare enumeration of instruments, to the organ builders of this country, so large has been the demand made on them of late years.

The *Barrel-Organ* is an instrument by which most of the effects of a small keyed-organ are produced by certain machinery. Instead of keys for the fingers, the keys, if so they may be called, are inside the organ, and acted on by means of a cylinder, or barrel, *pinned*, or studded in a particular and singularly curious manner. This barrel is made to revolve by a winch, and in those of an expensive kind by wheel-work moved by a spring.

The Apollonicon and the barrel-organ are described elsewhere. [APOLLONICON.]

ORGAN, CONSTRUCTION OF. We have on record several kinds of organs—the *Hydraulic*, the *Pneumatic*, the *Barrel*, and the *Finger* or *Church* organ.

Of the hydraulic organ we know little beyond its having been operated on in some way by water: it may have resembled the *clepsydra*, or water-clock, which chimed at certain hours; but as the passage of water through the pipes would not produce musical sounds, it is probable that water was employed as a moving power. Indeed, the plan of using water-power to work the bellows of an organ or harmonium has lately been revived, and the water engine may now be considered as an essential feature of an instrument which requires so large a supply of wind. The pneumatic organ, whether more or less ancient than the hydraulic, was certainly the parent of the present finger-organ; but it was so decidedly rude in its construction, that it must always be considered as a distinct instrument. The barrel-organ is a machine with little variety and no expression; it nevertheless contains many clever contrivances, and is daily receiving improvements. The present finger-organ is the largest and noblest of all musical instruments; its power is that of a full band, and for delicacy and sweetness of tone it is unrivalled.

In such an organ there are several thousand pipes, with arrangements for enabling the organist to make any single pipe of the number speak without disturbing any of the others. Now to do this there must be, 1, a bellows for supplying condensed air or *wind*; 2, a channel for conveying it to the pipe in question; 3, a valve, or some contrivance for admitting wind to this pipe when it is required to speak, and for cutting off the supply when it is required to be silent; 4, a lever for opening or shutting this valve. There are many other contrivances for producing variety of effect, loudness or softness, qualities of tone resembling various musical instruments, &c.

The sets of pipes in an organ are called *stops*; the corresponding notes of the different stops may agree in pitch, that is, they may be in unison; or they may produce a chord or an octave above. They differ however in quality of tone. Each stop is, in fact, a range of pipes of the same quality of tone, and extending throughout the compass of the instrument. When a certain stop is drawn, the keys will play throughout on pipes of that character of which the stop consists.

A complete and full finger organ should have *three sets of keys*, and at least *two octaves of pedals*.

The first set of keys takes the *swell*, the second the *great organ*, and the third the *choir*. The compass, as well as the size of organs, must depend upon circumstances. The German scale or compass is C C to F in alt; the English formerly descended to G below, but are now generally constructed on the German principle; the pedal organ taking the notes down to C C C, which, for duet and solo performances, is certainly the best. A good swell is always important to an organ, and we should recommend C C to F in alt as the compass to be preferred. The compass of the choir is generally the same as that of the great organ. These several parts, or organs, when brought together by stops, called *couplers*, give to the keys of the *great* organ the command of *every pipe in the instrument*, the power and majesty of which are without parallel in instrumental combinations.

Fig. 1 is a section of a large organ, showing the several situations of certain principal parts of the instrument, which, however, are variously placed by different organ-builders. A is the *swell-box*, which is usually made of deal, and the thicker the better, but it certainly should not be less than an inch and a half in thickness; it must be lined with paper or leather to deaden the tone when shut. The front is formed of *Louvre*-boards, all of which are made to move on centres; they must also be an inch and a half thick. The performer opens them by a pedal expressly employed for opening and shutting the swell. This kind of front is what is known by the name *Venetian*. B is the choir *sound-board*, or part in which the pipes of that part of the organ are placed; C is the great organ *sound-board*, which also contains its pipes; D is the *bellows*; E is the *pedal sound-board*; F is one of the front pipes, to which the wind is conveyed by metal tubes, called *conveyances*; G G G are three roller boards, one for each organ; H is a *tracker*, used with *squares* and *centres* to reach distant parts of the action; at I are the *keys;* at K are the *pedals;* L is the seat. The numerous things which are not indicated in this figure must be sought for in *working* drawings, as we cannot and do not pretend to give these matters a practical form.

Fig. 1.

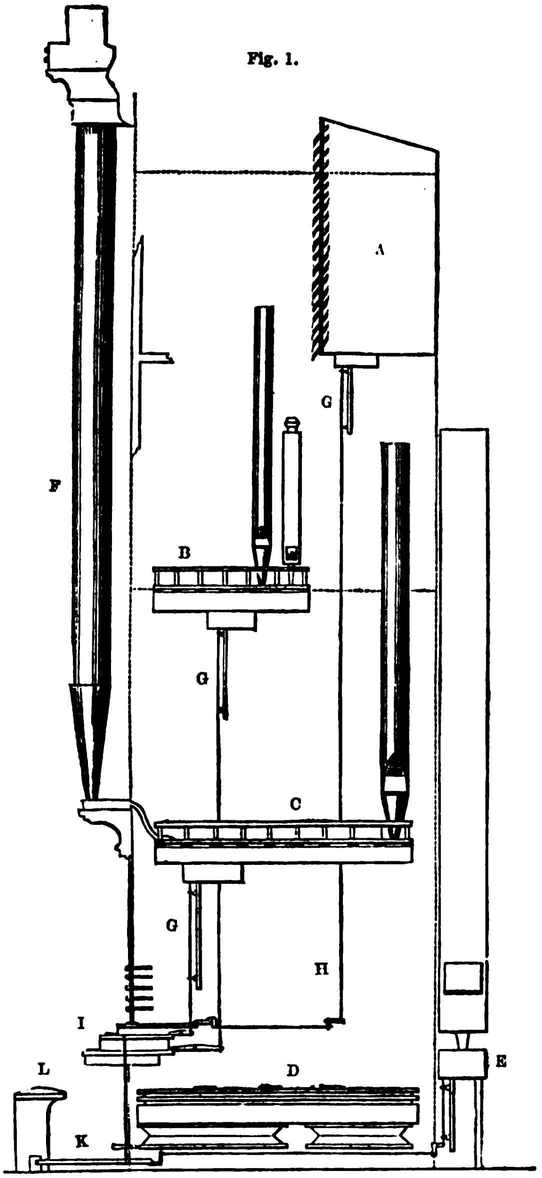


Fig. 2 represents what are called the *horizontal bellows.* A shows the *reservoir;* B, the deep frame through which the wind is taken; C, the part moved in blowing, called the *feeder;* D D, the *registrars,* by which the equal rising of the reservoir is ensured: there are valves inside for receiving and retaining the wind, all of which are differently constructed by different builders.

Fig. 2.

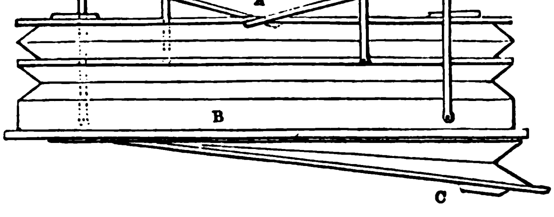


Fig. 3 is a perspective view of a *roller-board;* A A A, the board on which the rollers are fixed; B, three *pull-downs,* explained below; C C C, rollers centred at each end into small blocks, in which they move; there are also *arms* to each end, in front, connecting the rollers with the keys and the wind-chest; D, the levers which are connected with the keys and the pull-downs, and are longer or shorter as may be required; they are also *parallel* or *fan-like,* to suit their position.

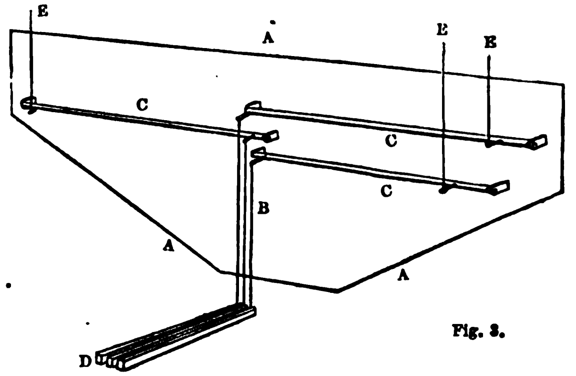
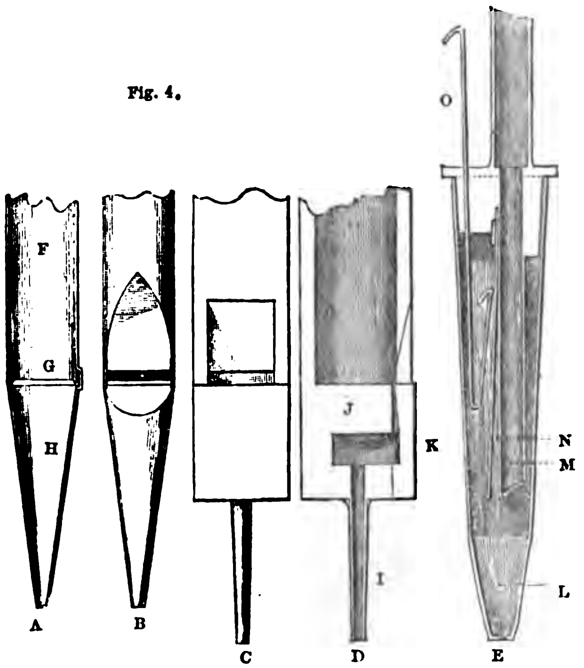


Fig. 3.

Fig. 4 contains a few examples of pipes. There are two general descriptions of pipe, namely, the *mouth, flute,* or *flue* pipe, and the *reed* pipe, each containing several different species. Mouth pipes have a mouth and lips like a flageolet; they may be of wood or metal, and the upper extremity may be open or closed by means of a plug, called a *tompion,* the effect of which is to lower the pitch a whole octave. The lower end is also closed with the exception of a narrow slit, which, in the pipes C and D, meeting a portion of the front wall bevelled to a sharp edge, forms what is called the *upper lip,* or *wind cutter.* The foot of the pipe fits into the apparatus or chest which supplies the pipes with wind. The blast from the narrow slit impinging on the upper lip is thrown into vibration, which it imparts to the whole column of air in the pipe, the result of which is a musical note, depending for its pitch on the length of the column thus set in motion. The voicing of the pipe is performed by paring away the upper lip; the upper part of the block is also toothed, so as to divide the plate of wind, or it would otherwise begin the note with a chirping noise. There are other precautions to be attended to, such as the width of the mouth. In metal mouth pipes, A B, the plate of wind is formed by the edge of the languette, by leaving a thin slit between the end of the languette and the lip. A is a metal open pipe; F, the sounding part; G, the part called the *languette,* and H, the *foot;* B is the same pipe, showing the *mouth* and the flattened part for *voicing;* C is a front view of a *stopped diapason* pipe; D is a section showing the arrangement of its construction; I is the *foot;* J is the *block,* and K is the *cap.* E is a section of the voice part of a *reed* pipe; L, the *foot;* M, the *mouth-piece;* N, the *reed;* and O, the *tuning-spring.* The pipe itself is made of a metal alloy of tin and lead; the *reed* is brass, and the *spring* is soft steel wire, about a tenth of an inch in diameter. By pushing down or drawing up the tuning-wire, the free part of the tongue is made shorter or longer. The tube above the cone or foot is variously shaped, and on it depends the *quality* of tone in reed pipes, the *pitch* being due

Fig. 4.



to the length, thickness, and elasticity of the tongue. This form of reed pipe is the basis of all the others, their differences being more in shape than in principle. There is however a distinction between the *free* reed and the *beating* reed, as explained below. [See also HARMONIUM.] When speaking of the lengths of pipes, it is generally with reference to *tuning* or *pitch* C, which is one foot long; and *all* C's *below are doubled* as we go from 1 to 2, 2 to 4, 4 to 8, 8 to 16, and 16 to 32; the last, although little used in this country, gives the highest rank to organs.

SPEAKING LENGTHS AND SEMIDIAMETERS OF STOPS.

	Open Diapason,	Principal, and	Fifteenth.
	F F F...........	F F F...........	F F F...........
	G G...........	....	....
8-foot pipe.	C C .... 8 feet....	C C, 4 feet........	C C, 2 feet........
	F F...........	....	....
	G ....Gamut..	....	....
4-foot pipe.	C....... Tenor ..	C pitch, 2 feet ... ⊙	C, 1 foot.........
	F...........	....	....
	G ...... Fiddle ..	....	....
2-foot pipe.	C ...... Middle . ⊙	C middle, 1 foot..	C, 6 inches.......
1-foot pipe.	C ...... Above ...	C above, 6 inches..	C, 3 inches.......

⊙

Centre to the above Semidiameters, which are real dimensions. This centre must be ½ an inch below the first dot.

This Table shows the relative lengths and diameters of the open *diapason*, the *principal*, and the *fifteenth stops*, as high as C above middle C.

Quints, *twelfths*, and *sesquialteras*, all take the sizes and lengths of their proper tones in the open diapason. *Trumpet* and *Oboe stops*, being what are called *unison stops*, also take their lengths from the *open diapason*. The *clarion*, an octave stop, is measured by the *principal*. The bells of all *reed-pipes* should be as large as their places in the organ will admit of.

Middle C in the *dulciana* is an inch and a quarter in diameter, and about two feet two inches long. A large size stop-diapason is seldom pure and musical. An inch and eighth wide and an inch and three-eighths deep, with thirteen inches in length, is a good scale for a *middle* C *stop-diapason pipe* in wood. Scales may be taken of larger or smaller dimensions, if desired, in which case the larger must be shorter and the smaller must be longer. Where stops are repeated, two or three of the same name, it is thought better to have them of different diameters, from an opinion that two or more unison-pipes of the same diameter affect the ear only as one pipe. There is something in this opinion, but how much we will not venture to determine.

Fig. 5 is a section of a *sound-board*, showing some part of the mechanism. A is the *rack-board*, by which the pipes are held in upright position; B shows the ends of the slides; C, that part of the sound-board which contains the *channels* for conveying the wind to the pipes; D, the pallet or valve which is opened by the finger of the organist, through the *key*, the *lever*, the *pull-down*, and the *roller* (see *Fig.* 7); E is the spring which keeps the pallet in its place when not in use; F is the *pull-down*, having a small screw and a leather button at one end, and a piece of hard bell-wire at the other; the former is fixed to the *lever*, and the latter to the *arm* of the *roller*; G is merely one end of the roller-board.

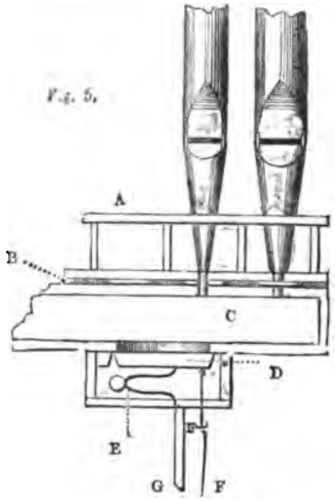


Fig. 5.

Fig. 6 represents a *draw-stop*, a *trundle*, and a *lever*, all of which are used by the organist in changing a stop or slide; A is the *draw-stop*; B is the *trundle*; C is the *lever*; D is the *slide*. The draw-stop is linked to the trundle at E, the trundle is linked to the lever at F, and the lever is fitted to the slide at G. Their centres are all at H. In connection with the above, there are also pedals called *composition pedals*, three, four, and five to an organ.

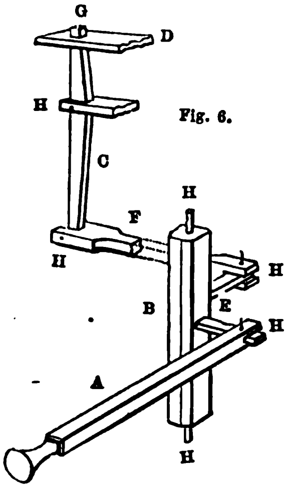


Fig. 6.

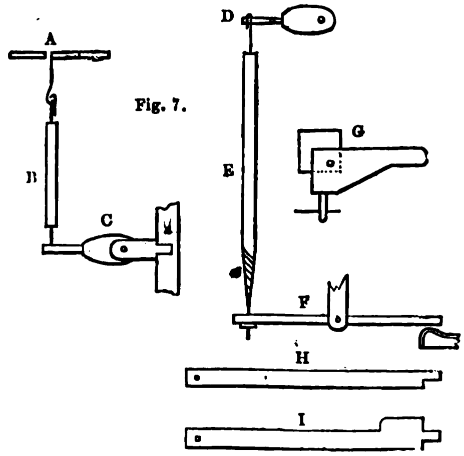


Fig. 7.

Fig. 7 represents certain small parts of the action. A is the wire by which the pallet is opened; B is the pull-down attached to it; C is the pallet-end of the roller, with its fixing to the board; D is an end view of a roller, with a pull-down and lever, all in their relative connection; E is the pull-down, and F is the lever, to which the key follows; G is a common form of a *square* or *centre*, by which the trackers are united. *Trackers* are pieces of pine wood, ⅜ of an inch wide, and from ⅛ to a ¼ thick; they are of different lengths, and may be used to any extent. The Birmingham organ is said to have four miles and a half of trackers in it. In the cathedral organ at Canterbury, they are employed to remove the keys to a distance from the instrument, which is done to the extent of ninety feet. H is the form of a pedal-key; I is the *sharp*, and H is the *natural*. The length is about two feet; the distance from centre to centre of each pedal is two inches and a half.

Fig. 8 represents an *anemometer*, or wind-gauge. It is a glass tube, bent as in the figure: the dark part is supposed to be water. A is the place to which it is applied in the organ, which is generally the hole for the pipe used as the pitch A or C. The pressure of the wind at B drives the water up to C, and the measure of their difference is what is called the *wind*. Some organs have more, and some less; two inches and a half is the common measure.

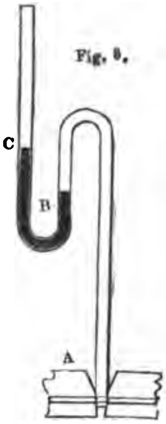


Fig. 8.

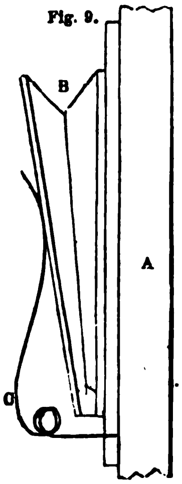
Fig. 9.


Fig. 9, represents a percussion valve. It may be said to be a small bellows pressed by a spring. A is the wind-trunk, to which it is fixed; B is the valve itself, and C is the spring. The use of this part of an organ is to steady the wind, which is sometimes disturbed by sudden transitions or very rapid performance: the spring of the valve is regulated so as to give way on such occasions and to moderate their effects.

Fig. 10 is a section of a common barrel-organ. A is the handle; B the *worm* and *crank*, which move the *barrel* and *bellows*; C is the barrel on which the tunes are set. The setting is effected by brass pins and staples driven into the barrel at proper distances, accordingly as the notes are longer or shorter. D is the key, the rising of which over the pins causes it to press down the sticker (E) into the wind-chest (F), and thus to open the pallet for the wind to enter the pipe above; G is the bellows; H, a stop-diapason pipe. This diagram shows only one barrel, which is the common plan, but Messrs. Gray and Co. have introduced three, by which great risk to the mechanism is avoided and much trouble is saved.

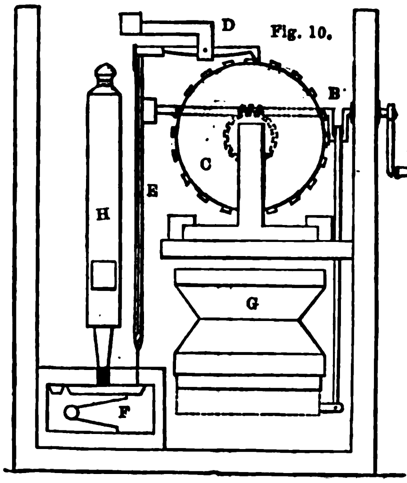


Fig. 10.

The tuning of organs is a subject on which there is much difference of opinion. Some tune from C, on the *unequal temperament*, and throw the imperfections on what is called the *wolf*, or key of four flats. Others tune from A, and adopt the *equal temperament;* this latter certainly has the better reasoning in its form, as it approaches nearer to the human voice, interferes less with the band, and is more agreeable in general modulation. This subject has been minutely handled by some scientific writers, who have given themselves the trouble of what may be called *splitting* octaves into *smaller intervals*. But the advantages of this minuteness have not yet extended beyond the schemers themselves, for not one of their methods has yet left the cradle of its birth. The Temple organ is said to have 14 sounds in the octave; the Foundling, 16; Hawke's patent, 17; Loeschman has 24, and Liston's enharmonic organ as many as 59, of which 24 are on the keys, and the rest on the pedals and other contrivances. If such schemes were to become general, they would make practical men tremble; but *flat fifths* are still in use notwithstanding the enharmonic divisions, and they have nothing to fear beyond an occasional dispute on the subject.

The numbers and kinds of stops are matters not subject to rule; they vary in almost every organ, and seem more under the command of circumstances, such as space and price, than any other parts of the instrument.

In treating the mechanism of the organ in so general a manner, we shall hardly be expected to point out all the improvements which have been made of late years in its various parts: a few however may be mentioned. Considerable strength both of hand and foot, as well as consummate musical skill, are required in an organist; the expenditure of wind also may vary from a few hundred to many thousand cubic feet per second. With a small expenditure of wind there is a greater elasticity of the air, and consequently a greater pressure against the valves so as to make them more difficult to open. The remedy for this was Mr. Barker's Pneumatic Lever, in which the elasticity of the air itself is made to overcome the resistances which had previously been thrown upon the organist. Mr. Willis has a contrivance for admitting wind to the pipes of the pedal-organ; it is formed by covering the aperture with a piece of leather, fixed at one end, and attached at the other to a wooden roller, so that when the latter is moved by the pedal key, it wraps the leather round it and so uncovers the opening, when the key is released a spring brings the roller back, and by unrolling the leather, again covers the aperture. Mr. Bishop's *Composition Pedals*, for opening and shutting the stops by the foot instead of the hand, are of great value, as is also his *Anti-concussion apparatus* for preventing the pulsation or concussion of air in the wind-chest, when a large number of pipes are made to cease speaking suddenly and a few only are held on. Mr. Willis has also introduced mechanical improvements for producing *crescendo* and *diminuendo* effects, enabling the player to draw or shut off any required number of the stops, one after the other in succession by one continuous movement, in contradistinction to the intermittent or repetition movements. Mr. Holt has introduced the *pneumatic lever*, or valve, to reed-pipes, so that when the wind is admitted it expands and causes a spring or jack tipped with india-rubber to strike the tongue and set it in motion, similar to the contrivance explained under HARMONIUM. The wind then keeps up the vibrations. By this contrivance the reeds may be made of thicker metal, and a fuller, rounder tone be produced. Lorenzi, of Paris, has introduced various novelties. The highly expressive tones of the organ depend principally on a repetition of sounds which succeed each other as the keys are touched. The keys act upon two stops, the first upon one pipe, and the second upon another in unison with it. The sound-board is divided into two parts with double valves, so that those of the first part admit wind to the pipes which are acted on only by the first stop, and those of the other part admit wind to the pipes which are acted on by the other stop. By pressing the key lightly to the first stop, and playing one note only, a soft sweet sound is produced; and by depressing the key entirely, the second stop is brought into action, and greater expression and power are thus attained. In this arrangement there may be a single sound-board in two parts, or two separate sound-boards may be used. The notes of the first part, particularly of the flute, bugle, and trombone stops, are of great delicacy and sweetness; and those of the other part, produced by the second series of stops, are of the greatest power and are occasionally double. The transition from *piano* to *forte* is not perceptible when the second note is commenced, but it is necessary to separate the first from the second part of the sound-board, as also of the pipes by enclosing them in a swell-box. By opening the swell the full power of the notes is obtained, without any violent transposition from piano to forte. The mechanism for effecting this is attached to a pedal, so that it may be disengaged from the keys when required. Another mode of giving expression and increasing the force by vibration or *trembling*, and increasing and decreasing the sound, when applied to the *fonochromic* organ with two valves, allows the performer gradually to augment the sound to double its usual force, and to diminish it again in the same manner, thus producing effects of a novel and delightful character. In order to obtain this result, an *expansive* bellows is employed; this forms a reservoir, and at the same time (on opening a valve) increases the force of the air nearly twofold. It is divided longitudinally into two parts, the part answering to ordinary bellows occupying three-fifths, the other part two-fifths, so as to make two bellows united. This smaller part communicates with the larger by means of a small valve placed above the hole, by which this second part receives the supply of air. There is also a valve which should remain open, and beside it another valve applied to a hole for the purpose of discharging the air from this part of the bellows. A very simple mechanism is employed for opening this latter discharging valve (no matter of what size the opening may be) and of shutting the other, so as to stop the communication with the other part of the bellows. By means of this mechanism, when the smaller bellows has discharged itself into the greater, the power of the latter is nearly doubled. It is worked by the same pedal which applies the trembling sound, and the same pedal also acts upon the swell-box containing the second series of pipes. These three movements are so arranged, that in depressing lightly the pedal, it acts only upon the mechanism of the trembling sound attached to the pipes acted upon by the first series of stops, and makes that note only vibrate; by depressing the key to the second stop the power of the note is greatly increased, and by then depressing the pedal further the note still increases in power; finally, when the pedal acts upon the mechanism of the expansive bellows, it gives a great volume of sound. The reverse process gradually diminishes the sound, but to reduce it to *pianissimo*, another pedal or lever under the key-board, worked with the knee (and hence called a *genual*), shuts some of the jalousies or lower-boards of the case enclosing the first series of pipes, and by this means the note is further diminished in force. These jalousies are disposed like those for the second series of pipes, but with the difference that in their state of repose they are open.

ORGANIC ANALYSIS is the generic term for a great number of chemical and physical operations, that have for their object the ascertaining of the composition and constitution of all matter that has been formed under the influences existing in animal and vegetable life. It also, of course, includes the similar examination of all derivatives and artificial imitations of the matter referred to.

In illustration of the above definition of organic analysis, let us suppose that we have for examination some well-known fruit, such as a pear. By processes presently to be described, we separate and isolate from it the matter or matters that appeal to the eye, in other words the colouring agent; similarly we obtain the odoriferous principle; then a matter that has no odour, but a distinct and well-defined taste; next we chemically dissect out the framework or skeleton; and finally turn our attention to the great mass of substance with which the framework is filled in. Operations are next undertaken by which we assure ourselves that the bodies thus separated are neither more nor less than what we suspect them to be; uniformity is here the great characteristic. Solid or liquid, the body in question must have a constant specific gravity; taste, odour, touch, must be unvaried; to the eye, alone or aided by the microscope, the appearance of each observable particle must be identical; if a fusible solid, it must have a constant melting point; if a volatile liquid, its boiling point must be unvarying. The next series of operations acquaints us with the number of elementary substances contained in each body under examination, as well as with the exact per centage amounts of those elements. Having now, to a certain extent, a knowledge of the composition of the bodies, we arrive at their probable constitution by a process of analogical reasoning; and this is confirmed or disproved by severally subjecting them to powerful chemical reagents. Possibly the latter cause the substances to be split into two or three bodies of more simple constitution; if so, they each must be passed through the prescribed ordeal. The odoriferous principle, for instance, of the pear has been isolated in a state of purity, and has been found to contain certain constant centesimal amounts of three elements; but on farther chemical examination it breaks up into two compounds, each of which however is found to possess uniform properties, and to have a constant centesimal composition. And now, having individualised and given character to each of the bodies under examination, we probably recognise them as old acquaintances, or possibly take to ourselves the merit of having discovered new ones. Our pear would yield us such bodies as water, starch, lignin, sugar, &c.; the flavouring principle, or essence of pears as we might call it, being found by the latter part of the examination to be a compound of acetic acid and oxide of amyl, or shortly the acetate of amyl. Several of the bodies enumerated may be artificially produced, their identity with the natural products being established by the similarity in their physical and chemical characters, especially as evidenced by their per centage composition.

From what has already been stated, it will be observed that organic analysis is either *proximate* or *ultimate*. The appearance and behaviour of bodies when acted upon by various reagents or tests may, when viewed by an experienced eye, be sufficient to establish their individuality, and their presence and even amount, in the matter originally operated on, may thus be satisfactorily determined: such is proximate organic analysis. But perhaps the bodies in question have no well-marked properties, or are possessed of characteristics not before observed in any known substance; in either case the number of their elementary constituents must be discovered, and the amount of each element ascertained; and such is ultimate organic analysis. Ultimate analysis also forms, as it were, the court of appeal from the decisions arrived at in proximate analysis.

Organic analysis and inorganic analysis are conventional divisions of chemical analysis. Each is subdivided into proximate and ultimate, and either one of the four classes is qualitative or quantitative in the sense of those words already alluded to under CHEMICAL ANALYSIS. The line of demarcation that separates these divisions is not very sharp; many bodies being found in animals and vegetables in a state not distinguishable from that in which they exist in the inorganic kingdom; such, of course, demand inorganic analytical treatment. Other bodies require modifications of organic or inorganic analysis, according to the nature of the substances with which they are associated, and from which they are to be isolated. The broad principles, however, of inorganic and organic analysis are pretty well defined, and the difference between them easy of practical recognition. While, on the one hand, inorganic analysis comprehends the manipulatory processes connected with the examination of metals and their salts: organic analysis, on the other hand, includes only operations which aid in discovering and investigating the apparently innumerable series of compounds formed by the union, in various ways, of the four elements—carbon, oxygen, hydrogen, and nitrogen.

Proximate Organic Analysis.

This is by far the more difficult branch of organic analysis. An animal or vegetable substance usually contains a much greater number of proximate principles than the most complex mineral; these principles have been built up by the agency of that mysterious aggregation of influences sometimes, though very unphilosophically, termed vital force; and, inasmuch as organic matter is necessarily only examined after those influences have been withdrawn, it follows that there is a constant tendency, as in all dead animal and vegetable matter, to return to its original more simple and stable condition. In addition to this source of complication, the bodies in question being held together by such weak affinities, are not only more readily acted upon and altered by the agents employed by the chemist to separate them, but very frequently act upon each other; so that, indeed, the perfect proximate analysis of organic matter is, in the present state of our knowledge, an impossibility; and the various published processes, professing to give a means of arriving at that desirable end, must be looked upon as being merely provisional. We are, however, able to isolate very many proximate principles, and it is quite admissible to include in an analysis such substances as "extractive matter," "balsamic matter," "resinous matter," "ethereal, alcoholic, aqueous, or alkaline extractive," &c., provided always that it be remembered that such names are only provisional, and that in future times, as in times gone by, an increasing number of definite principles will probably crop out from such collective substances, and finally their names be altogether expunged from proximate organic analysis.

We are indebted to Rochleder for the latest improvements in this department of chemistry. The process may shortly be stated as follows. (For further details see 'Pharmaceutical Journal' for 1860.)

The organic matter is first mechanically disintegrated. The more points of contact presented by a solid to the solvent action of a liquid, the better it is; so that comminution cannot well be carried too far. Often a certain degree of moisture renders the material tenacious and elastic, so that it is difficult of pulverisation; in that case a careful drying suffices to bring it into a pulverisable condition. Sometimes oily bodies cause the same kind of tenacity, and then expression of the cold or slightly warmed material will expedite matters. In other cases appropriate solvents may be used for the removal of bodies causing tenacity, and disintegration thus facilitated. If pulverisation cannot be accomplished by stamping or rubbing, recourse may be had to rasping, slicing, &c. Obviously much will depend upon the characteristic properties of the substance operated upon, so that no general rule can be laid down; at the same time, however, the above hints may give an idea of the methods to be adopted.

The material in a fine state of division is now divided into several portions, and each treated with a solvent, in order to obtain a number of extracts, which are to be submitted to farther examination.

One portion is boiled with water in a distillatory apparatus, by which a decoction and a distillate are obtained; the former will contain non-volatile constituents soluble in water, the latter volatile matters only. Another portion is treated with cold water, in order to dissolve out such matters as would be coagulated by the hot water. A third portion is heated in water acidulated with sulphuric acid, organic acids being thus set free and dissolved, and sulphates of alkaloids also extracted. The fourth operation is digestion in water rendered alkaline by ammonia, and for this the residue of the first operation may be employed. A fifth portion is subjected to the solvent action of alcohol, either cold, hot, strong, or weak, according to the nature of the material under examination; fats, oils, resins, and many bodies insoluble in water being thereby dissolved. The sixth process consists in treating with ether, which much resembles alcohol in its powers of solution, but differs in its action upon free fatty acids, and one or two other important bodies.

In addition to the above solvents, others are employed for special operations, as circumstances seem to indicate. Thus the alcohol or ether may be used in an acid or alkaline condition, as described for water; and benzole, chloroform, bisulphide of carbon, and similar liquids, may also be pressed into service under certain circumstances. As before stated, much must depend upon the knowledge, judgment, and observation of the experimenter.

The treatment of the several liquid extracts obtained as above described is the next point for consideration; but here the field of experiment becomes so greatly enlarged that anything like a detailed description of it would lead us far beyond the limits of the present article. Suffice it to say, that fractional distillation, fractional crystallisation, and fractional precipitation form the bases of operation adopted in the separation and isolation of organic proximate principles.

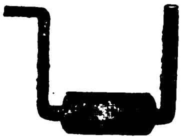
The examination of the residue after an organic material has been successively subjected to the action of the above liquids, is not a matter of very great difficulty, inasmuch as it can only consist of such substances as lignin and cellulose. Nor is it difficult to extract one proximate principle only from organic material, experience of the properties of similar principles here guiding to the most proper method.

The physical and chemical properties that should characterise an organic proximate principle have already been alluded to at the commencement of this article; it now, therefore, only remains to consider

Ultimate Organic Analysis.

From what has been stated, it is evident that this operation mainly consists in the determination of the quantities of carbon, hydrogen, oxygen, and nitrogen contained in any organic substance. Chlorine, bromine, iodine, sulphur, and phosphorus are comparatively very rarely met with; they are estimated in the manner described under each of those elements, or by some slight modification of the methods there given.

The first point to be attended to in an organic analysis, or combustion, as it is practically termed, is the removal of hygroscopic water—the removal of that moisture which most bodies absorb by mere contact with the atmosphere. This may be done in several ways; a very good one consists in placing the body over a surface of oil of vitriol under the receiver of an air-pump and exhausting, when complete desiccation speedily takes place. This process has the advantage of not requiring the application of heat, sometimes a point of great importance. Substances that bear a temperature of 212° Fahr. are dried either in a water oven, or are placed in a curved tube of the annexed form, which is introduced into boiling water and dry air drawn through it. Sometimes mere exposure to dried air at common temperatures is sufficient to desiccate a substance.



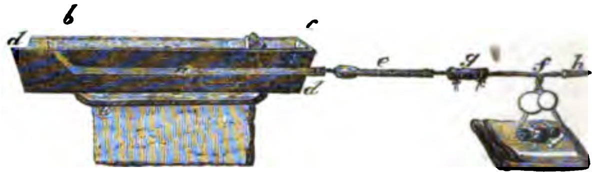
The next step in the process is the accurate weighing of the material. For this purpose the latter is usually inclosed in a small tube, and a balance employed that will indicate $\frac{1}{500}$th of a grain.

The following are the principles involved in the actual analysis:— First, of compounds containing *carbon*, *oxygen*, and *hydrogen*; for nitrogen must be estimated by a separate operation. It is well known that when coal or wood, or anything containing the three elements alluded to, is burned, the carbon takes up oxygen from the air and passes off under the form of carbonic acid, while the hydrogen combines with the quantity of oxygen requisite to form water and passes off as steam. Further, it is also well known that these combinations take place in fixed and unvarying proportions; that six parts of carbon always combine with sixteen of oxygen to form carbonic acid; and that one part of hydrogen always combines with eight parts of oxygen to form water. On these facts, then, is founded the process about to be described; for, obviously, if a weighed quantity of the wood, coal, &c., were taken, and the whole of the carbonic acid and water formed could be collected and weighed, we should be in possession of all the data required for finding the amounts of carbon, hydrogen, and oxygen originally present. The total amount of carbonic acid divided by 22 and then multiplied by 6, would give the quantity of carbon; the total amount of water divided by 9 would show the quantity of hydrogen; and the difference between the combined weights of the carbon and hydrogen, and the weight of the original substance, would give the quantity of oxygen.

The burning of the substance must be perfect; there must be no production of compounds intermediate between the original substance on the one hand, and the carbonic acid and water on the other. That the oxygen of the air is insufficient for this purpose is evident, when we remember that smoke is nearly always produced under such circumstances, and smoke is partly composed of those intermediate bodies, the production of which it is indispensable to avoid. The desired burning agent must, then, be one that will so readily yield its oxygen to organic matter at an elevated temperature, as to ensure complete oxidation of the substance to carbonic acid and water; at the same time it must be itself unalterable by the high heat employed. These apparently somewhat antagonistic properties are possessed by the black anhydrous oxide of copper. [COPPER.] About four or five grains of the powdered and dried substance are introduced into a tube (*a*, *fig.* 1) made of very infusible glass, about 15 to 20 inches long, nearly half an inch in diameter, drawn out to a point at one end (*b*, *fig.* 1), and previously about one-third filled up with oxide of copper that has been dried by igniting to redness and allowing to cool in a well-closed, long, narrow bottle: a little more oxide of copper is then poured in, and the substance well mixed with the oxide by means of a wire twisted at one end into a corkscrew shape; more oxide is again introduced, the wire passed once or twice through it to wash off adhering substance, and the tube finally filled up with oxide to within two inches of its open extremity. On heating this tube and its contents to redness, first near its open end (*c*, *fig.* 1), and then gradually throughout its whole length, the organic matter is thoroughly burnt into carbonic acid and water, the manner of separating and collecting which will presently be described.

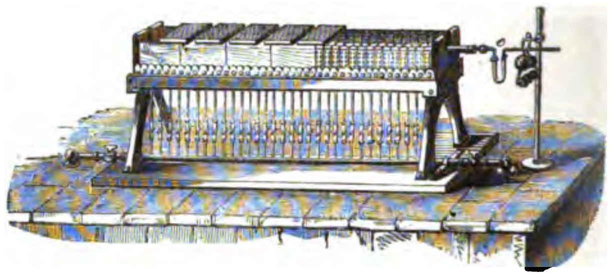
With regard to the best material for heating the tube, much must depend upon circumstances. Till within the last few years charcoal has been the fuel almost always employed, some pieces of which are made red-hot in a furnace, and then placed, a few at a time, first round the anterior part of the tube (*c*, *fig.* 1), the latter being supported on sheet-iron crosspieces in the sheet-iron trough, *d d*, represented in the accompanying drawing.

Fig. 1.



The combustion of charcoal, however, occasions a troublesome amount of dust, and, since the introduction of gas into laboratories, many furnaces have been contrived by means of which the glass tubes may be gradually and regularly heated with that fuel. The latest improvement in this respect is by Dr. Hofmann, the general arrangement of whose furnace is seen in *fig.* 2.

Fig 2.



In this apparatus the combustion of the gas is effected by means of a number of perforated clay burners, so grouped as to form a channel for the combustion tube, a system of stop-cocks permitting to confine the heat to any special place in which it may be required at the time.

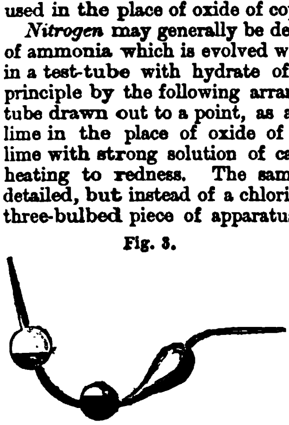
The arrangement by which the water and carbonic acid, formed during the operation from the organic substance, are collected, is very simple. A small glass tube, straight, as seen at *e*, *fig.* 1, or bent to the shape of the letter U, and having a bulb attached, as seen at *e*, *fig.* 2, is filled with pieces of fused chloride of calcium, and firmly fixed by a cork, or solid india-rubber plug, into the glass combustion tube. Immediately at the opposite extremity of the chloride of calcium tube a piece of apparatus, known as 'Liebig's potash bulbs' (*f*, *fig.* 1), is attached by a piece of india-rubber tubing (*g*). The vapour of water and carbonic acid evolved from the tube are thus thoroughly absorbed, the former by the chloride of calcium, and the latter by a strong solution of caustic potash previously placed in the bulbs. The whole length of the tube having been brought to a red heat, and there maintained till no more bubbles of gas pass into the potash, the charcoal is removed from the extremity, the little point *b* broken off, and air cautiously drawn through the whole arrangement by aspiration, with a piece of india-rubber tubing attached to the potash bulbs. In this last operation loss may be occasioned by the air carrying a little vapour of water away from the potash solution, and hence the use of the little tube *h*, which contains a short stick of solid hydrate of potash. In place of driving out the residual vapour of water and carbonic acid by air, a few fragments of chlorate of potash may be placed in the posterior extremity of the tube; and on heating this at the close of the operation, evolution of oxygen takes place, and effects the desired object. The use of chlorate of potash here is attended with two or three advantages, but it is liable to be decomposed so rapidly as to blow some of the solution of potash altogether out of the bulbs. Another and greater modification of the process consists in having a considerable elongation of the tube in the place of the little capillary extremity above described: into this open end a little platinum or porcelain boat, containing the organic substance to be analysed, can be placed, and a stream of pure and dry air or oxygen passed over it. On then gradually heating the glass tube in the neighbourhood of the boat, the substance burns as it would do in air; but the products of combustion pass on over the ignited oxide of copper, and are collected respectively in the chloride of calcium tube and potash bulbs. At the same time any inorganic, non-volatile matter present in the organic substance remains in the boat as ash, and may readily be removed and examined.

Volatile liquids may be burnt in either of the above modifications of combustion tube, but are first inclosed in little bulbs having thin necks that can easily be broken.

With substances not readily burnt, chromate of lead is sometimes used in the place of oxide of copper.

Nitrogen may generally be detected in an organic body by the odour of ammonia which is evolved when a little of the substance is heated in a test-tube with hydrate of potash. It is estimated on the same principle by the following arrangement of apparatus. A combustion-tube drawn out to a point, as already described, is charged with soda-lime in the place of oxide of copper. Soda-lime is made by slaking lime with strong solution of caustic soda, evaporating to dryness, and heating to redness. The same precautions are observed as before detailed, but instead of a chloride of calcium tube and potash bulbs, a three-bulbed piece of apparatus, of the annexed form, is attached to the open end of the combustion-tube, and is charged with moderately strong hydrochloric acid. The acid absorbs the ammonia that is evolved on gradually heating the tube to redness; residual ammonia being driven into the acid by a current of air drawn through the whole arrangement in the manner already indicated. If nitrogen be present in an organic substance it is liable, when burnt with oxide of copper, to pass off in the state of acid-oxides absorbable by potash, hence the estimation of carbon and hydrogen must only be proceeded with after a small bundle of copper turnings have been placed just inside the combustion-tube; this, when heated to bright redness, effects the decomposition of the oxides into non-absorbable nitrogen and oxygen.

Fig. 3.



So much for the practical operations connected with ultimate organic analysis. The weights of the chloride of calcium tube and potash-bulbs having been ascertained, both before and after the combustion, a few simple calculations suffice for ascertaining the percentage amounts of the elements present. These calculations will perhaps be most easily described by an illustration. Suppose that sugar were the substance experimented on, then :—

Quantity of sugar taken	4·75 grains.
Potash apparatus—	
After experiment	781·13 „
Before „	773·82 „
Carbonic acid	7·31 „
Chloride of calcium tube—	
After experiment	226·05 grains.
Before „	223·30 „
Water	2·75 „

7·31 grains carbonic acid contain 2·0213 grains of carbon.
2·75 „ water contain ·3056 „ hydrogen.

Or, in one hundred parts—

Carbon	42·55
Hydrogen	6·43
Oxygen (by difference)	51·02
	100·00

The percentage of nitrogen is calculated from somewhat different data. The acid liquid in the bulbs containing chloride of ammonium, formed by the combination of the ammonia with the hydrochloric acid, is placed in a small capsule, bichloride of platinum added to it, the whole evaporated to dryness over a water-bath, the residue washed with a mixture of alcohol and ether, and the insoluble crystals of the double chloride of platinum and ammonium collected upon a tared filter and weighed: 220·52 grains of such crystals contain 14 grains of nitrogen, their weight, therefore, and the amount of the substance operated on being known, the percentage quantity of nitrogen contained in the matter under examination is easily calculated.

To determine the equivalent or combining proportion of an organic compound necessarily forms an important part of the labours of an analyst, and cannot be deduced merely from the data yielded by the operations that have been described. It is, however, ascertained with tolerable ease, if the compound can be made to unite and form a definite salt with some body, the combining proportion of which is already well known. An analytical operation having then shown how much of the well-known body is thus introduced, an easy calculation indicates how much of the organic compound would combine with one equivalent of the other matter, and this number is obviously the combining proportion of the organic compound. This point having been obtained, theoretical considerations and the data obtained from combustion conduct to a formula for the compound submitted to organic analysis.

ORGANIC BASES. Under the definition of the term BASE, the *organic bases*—or the bases derived from animals and vegetables—have been alluded to. The source, preparation, properties, &c., of these *natural* bases or alkaloids are detailed under their respective names, [CINCHONA, ALKALOIDS OF; CONINE; NICOTINE; NUX VOMICA, ALKALOIDS OF; OPIUM, ALKALOIDS OF, &c.] The *artificial* organic bases have not been so fully described, and indeed in most cases only cursorily noticed in the article on the body from which they are derived. The present article will therefore be devoted to a description of the modes of formation and general properties of the artificial organic bases, prefaced by a brief review of the probable constitution of the organic bases generally.

A prominent characteristic of organic bases is the presence of nitrogen; they all contain nitrogen. The nitrogenous principles in animals are, of course, directly or indirectly obtained from vegetables; and the nitrogen in vegetables is known to be derived from ammonia. Nearly all artificial organic bases are actually built up from ammonia; and, moreover, artificially or naturally formed, they all retain the character of basicity, which is the chief chemical property of ammonia. Following then such strong presumptive evidence, chemists have of late years referred the organic bases to the simple typical body ammonia, and have in most cases succeeded in showing how they are constructed upon, or at all events derived from, the type NH_3 (*amines*). Berzelius was the first to suggest that the basic character of the alkaloids was intimately connected with ammonia. To the prophetic sagacity of Liebig, however, are we indebted for the idea that they were derivatives of ammonia; that they were, in fact, amidogen bases or ammonia (NH_3) in which an equivalent of hydrogen is replaced by an electro-positive radical. Following out this idea Wurtz succeeded in obtaining several such bodies; but it is chiefly to the remarkable and laborious investigations of Dr. Hofmann that we are indebted for the very complete knowledge which we possess of this interesting class of organic compounds.

Amines, is a frequent collective title of the organic bases that are derivatives of NH_3. The amines may be :—1. *Monamines;* 2. *Diamines;* 3. *Triamines;* 4. *Tetramines;* or, 5. *Pentamines*, according as they seem to be constructed upon a single, double, triple, quadruple, or quintuple atom of NH_3.

1. *Monamines*. This class is constructed upon a single typical atom of ammonia, namely, $\left.\begin{matrix}H\\H\\H\end{matrix}\right\}N$. *Primary* monamines contain only one of the three atoms of hydrogen (H) replaced by a radical (R); their general formula is therefore $\left.\begin{matrix}R\\H\\H\end{matrix}\right\}N$. *Secondary* monamines contain two atoms of radical, thus, $\left.\begin{matrix}R\\R\\H\end{matrix}\right\}N$; and moreover the radicals may be similar or different ones. Here we get the first glimpse, and a very faint one, too, of the inconceivable numbers of organic bases that possibly exist; for of twenty radicals the first may be occupying the place of one equivalent of hydrogen in a secondary monamine, while each of the remaining nineteen successively occupy the place of the other equivalent of hydrogen, a new organic base being each time produced. Similarly the second of the twenty radicals may be keeping its place, while the remaining eighteen are consecutively introduced, and another batch of bases formed; and thus with only twenty simple radicals nearly two hundred secondary monamine bases may be obtained. But there are many more than twenty radicals, and each successive one would of course introduce a greater number of changes, and produce, therefore, a greater number of compounds than its predecessor. Moreover each simple radical possesses its own chlorine, bromine, iodine, peroxide of nitrogen, &c., derivative, and of course each of these might keep its place in a secondary monamine, while innumerable changes were being rung upon the second radical. Indeed it is useless endeavouring to pursue these calculations farther; we have only got into the second of twelve classes, and already view such a number of organic bases as would defy the powers of the most zealous experimenter to produce and examine. When, again, it is remembered that the next class, the *tertiary* monamines $\left.\begin{matrix}R\\R\\R\end{matrix}\right\}N$ must contain a far greater variety, an indistinct notion can be obtained of the number of changes that may take place in the still higher classes. The general formulæ of the monamines are obviously six :—

$$\underset{a.}{\left.\begin{matrix}R\\H\\H\end{matrix}\right\}N}\qquad\underset{b.}{\left.\begin{matrix}R\\R\\H\end{matrix}\right\}N}\qquad\underset{c.}{\left.\begin{matrix}R\\R\\R\end{matrix}\right\}N}\qquad\underset{d.}{\left.\begin{matrix}R''\\H\end{matrix}\right\}N}\qquad\underset{e.}{\left.\begin{matrix}R''\\R\end{matrix}\right\}N}\qquad\underset{f.}{R'''\}N}$$

a. Primary monamines, sometimes called *amidogen bases*, such as ethylamine $\left.\begin{matrix}C_4H_5\\H\\H\end{matrix}\right\}N$. *b*. Secondary monamines, like diethylamine $\left.\begin{matrix}C_4H_5\\C_4H_5\\H\end{matrix}\right\}N$. *c*. Tertiary monamines, *e.g.* triethylamine $\left.\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right\}N$. *d*. Secondary monomines—or *imidogen bases*, as they have occasionally been termed—containing a diatomic radical (R′′) in the place of two equivalents of hydrogen, *e.g.*, conylamine (conine) $\left.\begin{matrix}(C_{16}H_{14})'' \\ H\end{matrix}\right\} N$. *e.* Tertiary monamines containing a diatomic radical, as, for instance, methyl-conylamine (methyl-conine) $\left.\begin{matrix}(C_{16}H_{14})'' \\ C_2H_3\end{matrix}\right\} N$. *f.* Tertiary monamines containing a triatomic radical (R′′′) in the place of three equivalents of hydrogen, examples of them are seen in picoline $(C_{12}H_7)'''\}N$, and leucoline $(C_{18}H_7)'''\}N$.

2. *Diamines.* These bodies are formed upon the type of two atoms of ammonia, or diammonia $\left.\begin{matrix}H_3 \\ H_2 \\ H_2\end{matrix}\right\} N_2$, or $\left.\begin{matrix}H\,H \\ H\,H \\ H\,H\end{matrix}\right\} N\,N$. A great number of organic bases belonging to this type have already been formed; not only primary, secondary, and tertiary, but belonging to intermediate divisions, the construction of which will be readily understood on looking over the annexed list of the general formulæ of diamines :—

$$\left.\begin{matrix}RH \\ HH \\ HH\end{matrix}\right\}NN \quad \left.\begin{matrix}RR \\ HH \\ HH\end{matrix}\right\}NN \quad \left.\begin{matrix}RR \\ RH \\ HH\end{matrix}\right\}NN \quad \left.\begin{matrix}RR \\ RR \\ HH\end{matrix}\right\}NN \quad \left.\begin{matrix}RR \\ RR \\ RH\end{matrix}\right\}NN \quad \left.\begin{matrix}RR \\ RR \\ RR\end{matrix}\right\}NN$$

$$\left.\begin{matrix}R'' \\ HH \\ HH\end{matrix}\right\}NN \quad \left.\begin{matrix}R'' \\ RH \\ HH\end{matrix}\right\}NN \quad \left.\begin{matrix}R'' \\ RR \\ HH\end{matrix}\right\}NN \quad \left.\begin{matrix}R'' \\ RR \\ RH\end{matrix}\right\}NN \quad \left.\begin{matrix}R'' \\ RR \\ RR\end{matrix}\right\}NN \quad \left.\begin{matrix}R'' \\ R'' \\ HH\end{matrix}\right\}NN$$

$$\left.\begin{matrix}R'' \\ R'' \\ RH\end{matrix}\right\}NN \quad \left.\begin{matrix}R'' \\ R'' \\ RR\end{matrix}\right\}NN \quad \left.\begin{matrix}R'' \\ R'' \\ R''\end{matrix}\right\}NN \quad \left.\begin{matrix}R''' \\ HH \\ H\end{matrix}\right\}NN \quad \left.\begin{matrix}R''' \\ RH \\ H\end{matrix}\right\}NN \quad \left.\begin{matrix}R''' \\ RR \\ H\end{matrix}\right\}NN$$

$$\left.\begin{matrix}R''' \\ RR \\ R\end{matrix}\right\}NN \quad \left.\begin{matrix}R''' \\ R'' \\ H\end{matrix}\right\}NN \quad \left.\begin{matrix}R''' \\ R'' \\ R\end{matrix}\right\}NN \quad \left.\begin{matrix}R''' \\ R'''\end{matrix}\right\}NN \quad \left.\begin{matrix}R'''' \\ HH\end{matrix}\right\}NN \quad \left.\begin{matrix}R'''' \\ RH\end{matrix}\right\}NN$$

$$\left.\begin{matrix}R'''' \\ RR\end{matrix}\right\}NN \quad \left.\begin{matrix}R'''' \\ R''\end{matrix}\right\}NN \quad \left.\begin{matrix}R''''' \\ H\end{matrix}\right\}NN \quad \left.\begin{matrix}R''''' \\ R\end{matrix}\right\}NN \quad R''''''\}NN$$

The immense number of bodies that may be represented by any one of these general formulæ may perhaps be obscurely imagined on applying, to either of the first half dozen, the remarks made under the head of secondary monamines.

The following list of examples of diamines is given in illustration of the above general formulæ. Some of the latter, however, have no actually-obtained representatives among the organic bases, although the greater number of them have among the organic neutral principles. [AMIDES.]

$$\underbrace{\left.\begin{matrix}(C_2N)H \\ (C_{12}H_5)\ (C_{12}H_5) \\ H \qquad\quad H\end{matrix}\right\}NN}_{\text{Melaniline.}} \quad \underbrace{\left.\begin{matrix}(C_2N)H \\ (C_{12}H_5)\ (C_{12}H_5) \\ (C_{12}H_5)H\end{matrix}\right\}NN}_{\text{Cyan-triphenyl-diamine.}} \quad \underbrace{\left.\begin{matrix}(C_2H_3)\ (C_2H_3) \\ (C_2H_3)\ (C_4H_3) \\ (C_4H_3)\ (C_4H_3)\end{matrix}\right\}NN}_{\text{Trimethyl-trivinyl-diamine (Acetonine ?).}}$$

$$\underbrace{\left.\begin{matrix}(C_2O_2)'' \\ HH \\ HH\end{matrix}\right\}NN}_{\text{Urea.}} \quad \underbrace{\left.\begin{matrix}(C_2O_2)'' \\ (C_4H_5)H \\ H\ \ H\end{matrix}\right\}NN}_{\text{Ethyl-urea.}} \quad \underbrace{\left.\begin{matrix}(C_2O_2)'' \\ (C_4H_5)\ (C_6H_5) \\ H \qquad H\end{matrix}\right\}NN}_{\text{Ethyl-allyl-urea.}}$$

$$\underbrace{\left.\begin{matrix}(C_2O_2)'' \\ (C_4H_5)H \\ (C_{10}H_{10})''\end{matrix}\right\}NN}_{\text{Ethyl-piperyl-urea.}} \quad \underbrace{\left.\begin{matrix}(C_4H_4)'' \\ (C_4H_4)'' \\ (C_{12}H_5)\ (C_{12}H_5)\end{matrix}\right\}NN}_{\text{Diethylene-diphenyl-diamine.}} \quad \underbrace{\left.\begin{matrix}(C_{14}H_6)'' \\ (C_{14}H_6)'' \\ (C_{14}H_6)''\end{matrix}\right\}NN}_{\text{Tristilbyl-diamine (Amarine ?).}}$$

$$\underbrace{\left.\begin{matrix}(C_4H_3)''' \\ HH \\ H\end{matrix}\right\}NN}_{\text{Acetdiamine.}} \quad \underbrace{\left.\begin{matrix}(C_2H)''' \\ (C_{12}H_5)\ (C_{12}H_5) \\ H\end{matrix}\right\}NN}_{\text{Formyl-diphenyl-diamine.}} \quad \underbrace{\left.\begin{matrix}(C_{10}H_7)''' \\ (C_{10}H_7)'''\end{matrix}\right\}NN}_{\text{Dinicotyl-diamine (Conine ?).}}$$

A peculiar class of organic bases designated by the term *phosphamines* seem to be diamines, corresponding in constitution to urea. $\left.\begin{matrix}(C_2S_2)'' \\ (C_4H_5)\ (C_4H_5) \\ (C_4H_5)\ C_{12}H_5\end{matrix}\right\} NP$, is such a body formed by the action of sulpho-cyanide of phenyl upon triethylphosphine. It contains an equivalent of phosphorus in the place of one of nitrogen. This class has at present only few members, but inasmuch as many monamines exist containing not only phosphorus but arsenic and antimony, in the place of nitrogen, it is possible that the NN in diamines may be replaced by PP, As As, Sb Sb, and by NAs, NSb, PAs, PSb, and As Sb the same as by NP, as seen in the formula of the phosphamine just given.

3. *Triamines,* derived from a triple atom of ammonia or triammonia. The same general remarks that have applied to the monamines and diamines apply also to this third class. Although many natural organic bases contain three equivalents of nitrogen, and may be represented as triamines, it is not positively known that they really are so, and at present only two artificial bases possess the triammonic character at all decidedly; they are :—

Melamine (tricyan-triamine) . . . . $\left.\begin{matrix}(C_2N)_3 \\ H_3 \\ H_3\end{matrix}\right\} N_3$

and

Cyanethine (triallyl-triamine) . . . . $\left.\begin{matrix}(C_6H_5)''' \\ (C_6H_5)''' \\ (C_6H_5)'''\end{matrix}\right\} N_3$

4. *Tetramines.*—Theobromine and caffeine contain four equivalents of nitrogen, and may possibly be tetramines. The only well marked artificial one is glycosine (not glycocin), containing the hypothetical tetratomic radical glycyl $(C_4H_2)''''$; its formula is $\left.\begin{matrix}(C_4H_2)'''' \\ (C_4H_2)'''' \\ (C_4H_2)''''\end{matrix}\right\} N_4$, and its explanatory name would be triglycyl-tetramine.

5. *Pentamines* have no representatives among the strictly organic bases. Some cobalt bases that have recently been discovered seem to be pentammonic.

Ammoniums.—When ammonia (NH_3) is dissolved in water a solution is obtained having all the characters of the hydrated oxides of the alkali metals, and is by analogy looked upon, therefore, as containing the hydrated oxide of ammonium $\left(NH_4O,\ HO, \text{ or } \left.\begin{matrix}H_4N \\ H\end{matrix}\right\} O_2, \text{ or } \left.\begin{matrix}HHHHN \\ H\end{matrix}\right\} O_2\right)$. Similarly when the monamines, whose general formulæ have already been given, are dissolved in water, hydrated oxides of organic bases are produced of the general formula $\left.\begin{matrix}RHHHN \\ H\end{matrix}\right\} O_2$, or $\left.\begin{matrix}RRHHN \\ H\end{matrix}\right\} O_2$, or $\left.\begin{matrix}RRRHN \\ H\end{matrix}\right\} O_2$, and having the termination -monium in place of the original -ine. Thus, ethylamine furnishes hydrated oxide of ethylammonium, and di- and tri-ethylamine yield hydrated oxides of di- and tri-ethylammonium. This change of constitution, and therefore of typical expression, is, moreover, warranted by the fact that the fourth equivalent of hydrogen in ammonium may be replaced, and organic bases of the general formula $\left.\begin{matrix}RRRRN \\ H\end{matrix}\right\} O_2$ readily produced; such an one is the hydrated oxide of tetrethylammonium $\left.\begin{matrix}(C_4H_5)_4N \\ H\end{matrix}\right\} O_2$, and the corresponding compound of methyl-ethyl-amyl-phenyl-ammonium—

$$\left.\begin{matrix}(C_2H_3)\ (C_4H_5)\ (C_{10}H_{11})\ (C_{12}H_5)\ N \\ H\end{matrix}\right\} O_2.$$

In the ammoniums, as in the amines, biatomic (R′′), teratomic (R′′′), and quadratomic (R′′′′) radicals may replace two, three, or four equivalents of hydrogen respectively. There seem also to be compounds conveniently represented on the ammonium type as ammonium in which hydrogen is replaced by ammonium itself, or rather by a derivative of ammonium, but at present only two organic bases can be thus viewed. Finally, there are good indications of the existence of di-ammonium and tri-ammonium organic bases derived from double and triple atoms of hydrated oxide of ammonium, and resembling the diamine and triamine bases.

Formation of Organic bases.

The modes in which the natural organic bases are formed are not yet ascertained, for all attempts to produce them artificially have hitherto failed. The artificial bases are formed by several processes, which we now propose to notice, including under each a list of the chief bases produced.

First. Direct substitution of organic radicals for the hydrogen in ammonia. This process will be readily understood by the following example. A mixture of strong alcoholic solution of ammonia with iodide of ethyl is hermetically sealed up in a long tube and heated for some hours in a water-bath; combination takes place, and the result is hydriodate of ethylamine $\left(\left.\begin{matrix}C_4H_5 \\ H \\ H\end{matrix}\right\} N,HI\right)$. On distilling the latter with potash, iodide of potassium, water, and *ethylamine* $\left(\left.\begin{matrix}C_4H_5 \\ H \\ H\end{matrix}\right\} N\right)$ are formed. On now going through the same process, but using ethylamine instead of ammonia, *diethylamine* $\left.\begin{matrix}C_4H_5 \\ C_4H_5 \\ H\end{matrix}\right\} N$ is obtained. On subjecting diethylamine to the same method we produce *triethylamine* $\left(\left.\begin{matrix}C_4H_5 \\ C_4H_5 \\ C_4H_5\end{matrix}\right\} N\right)$. Triethylamine unites directly with iodide of ethyl, and the result is the formation of the iodide of tetrethylammonium $\left.\begin{matrix}C_4H_5 \\ C_4H_5 \\ C_4H_5 \\ C_4H_5\end{matrix}\right\} N,I = (C_4H_5)_4\,N,I$. On now treating this iodide with freshly-precipitated oxide of silver, iodide of silver is formed, and the *hydrated oxide of tetrethylammonium* set free. The latter body is a powerful base, comparable only with caustic potash or soda. It saponifies oils, precipitates metallic oxides from their salts, is not volatile without decomposition, rapidly absorbs carbonic acid and water from the air, is itself crystalline, and forms crystalline salts with acids, turns red litmus-paper blue, dissolves the cuticle, and, in short, behaves as though it were an inorganic alkali. Ethylamine is a colourless, volatile liquid of sp. gr. 0·696; vapour density, 1·594; soluble in water in all proportions; acts like ammonia upon solutions of metallic salts, but, unlike ammonia, it dissolves recently-precipitated alumina. Diethylamine is also colourless, volatile, inflammable, and caustic; boiling point, 134·6°. Triethylamine resembles ethylamine and diethylamine, and forms a beautiful orange-coloured crystalline salt with bichloride of platinum, containing ($(C_4H_5)_3$ N, HCl, $PtCl_2$).

So much for the general method of procuring the greater part of the organic bases. Of course the iodide, and sometimes the bromide or chloride, of *any* alcohol radical may be employed, the amines formed containing that radical in the place of the ethyl in the example quoted. Moreover a primary amine may be acted upon by the iodide of a radical other than that it already contains, and the secondary amine thus formed acted upon by the iodide of a third radical different from either of the two existing in it, and finally the tertiary amine thus produced may be made to unite with the iodide of a fourth alcohol radical, and an ammonium called into existence having the four equivalents of hydrogen substituted by four different electro-positive radicals.

This method is important, not only in producing new organic bases, but as a means of ascertaining the constitution of an organic base after its composition has been determined by organic analysis. For obviously, if the base will only unite with one molecule of an alcohol radical, it must be a tertiary monamine; if with two, a secondary monamine; if with three, a primary monamine. The process does not, however, tell us in all cases whether the unknown radical already present in the body is monatomic, diatomic, or teratomic. The natural bases conine and codeine have in this way been shown to be secondary and tertiary monamines respectively, while nicotine, quinine, cinchonine, quinidine, brucine, and strychnine are either tertiary monamines or tertiary diamines.

The following organic bases, mostly formed by the above general method, have already been mentioned in this Cyclopædia, but for details concerning them, have been referred to the present article. Their general properties are similar to those of the ethyl derivatives fully described above; their special characteristics will only therefore be given.

Methylamine (N, H_2, C_2H_3) is frequently met with in organic decompositions; it is a gas, but may be condensed by a freezing mixture; it is inflammable, and at 55° Fahr. water dissolves 1150 times its bulk. *Dimethylamine* has not been isolated in a pure state. *Trimethylamine* ($N(C_2H_3)_3$) may often be recognised by its odour in the roe of herrings; it boils at 41° Fahr. and is inflammable. *Tetramethylammonium*, hyd. ox. ($N(C_2H_3)_4$, O, HO), crystallises in deliquescent needles; its salts also crystallise well. *Methyltriethylammonium*, hyd. ox. (NC_2H_3, $(C_4H_5)_3$, O, HO) is crystalline; its salts are very soluble in water. *Propylamine* ($NH_2C_6H_7$) has not been much studied. *Butylamine* ($NH_2C_8H_9$) is a colourless liquid, lighter than water; boiling point about 176° Fahr.; it forms stable crystalline salts. *Amylamine* (NH_2, $C_{10}H_{11}$) boils at 203° Fahr.; has a specific gravity of 0·7503, and is inflammable. *Diamylamine* ($NH(C_{10}H_{11})_2$) boils at 338° Fahr. *Triamylamine* ($N(C_{10}H_{11})_3$) boils at 494°·6 Fahr., and much resembles diamylamine. *Methyl-ethyl-amylamine* ($NC_2H_3C_4H_5C_{10}H_{11}$) is a colourless oil of agreeable aromatic odour; boiling point, 275° Fahr. *Diethyl-amylamine* ($N(C_4H_5)_2C_{10}H_{11}$) boils at 309°·2 Fahr., and with iodide of methyl gives the iodide of *methyl-diethyl-amyl-ammonium*. *Tetramyl-ammonium*, hyd. ox. ($N(C_{10}H_{11})_4$O HO) occurs in deliquescent crystals. *Amyltriethylammonium*, hyd. ox. ($N(C_{10}H_{11})(C_4H_5)_3$O HO) forms crystalline salts, but is not crystalline itself. *Tricetylamine* ($N(C_{32}H_{33})_3$) crystallises in colourless needles; melting point, 102·2° Fahr. *Allylamine* ($NH_2C_6H_5$) distils between 356° and 374° Fahr.

A second method of forming organic bases is by the reduction of nitro-compounds. Many organic bodies suffer substitution of peroxide of nitrogen for hydrogen, when they are acted upon by nitric acid. The resulting nitro-compounds undergo a remarkable transformation when subjected to the influence of nascent hydrogen, sulphuretted hydrogen and other well-known reducing agents, NH_2 or H_2 taking the place of NO_4 or O_4. Thus benzole ($C_{12}H_6$) yields nitrobenzole ($C_{12}H_5NO_4$) on being acted upon by nitric acid; and nitrobenzol furnishes the organic base *phenylamine* ($NH_2C_{12}H_5$), or ANILINE, on being treated with sulphuretted hydrogen, thus:—

$$\underbrace{C_{12}H_5NO_4}_{\text{Nitrobenzol.}} + \underbrace{6HS}_{\substack{\text{Sulphuretted}\\ \text{hydrogen.}}} = \underbrace{NH_2C_{12}H_5}_{\text{Phenylamine.}} + \underbrace{4HO}_{\text{Water.}} + \underbrace{S_6}_{\text{Sulphur.}}$$

In a similar manner there have been formed *tolylamine* (toluidine) ($NH_2C_{14}H_7$); *xylylamine* (xylidine) ($NH_2C_{16}H_9$); *cumylamine* (cumidine) ($NH_2C_{18}H_{11}$); and *naphtylamine*, $NH_2(C_{20}H_7)$. Many derivatives of these compounds have been formed by applying the substitutive processes described under the first method: the following are the chief of them. *Methyl-phenylamine* ($NHC_2H_3C_{12}H_5$), a fragrant oil, boiling at 377·6° Fahr. *Ethyl-phenylamine* ($NHC_4H_5C_{12}H_5$), sp. gr. 0·954; boiling point 400° Fahr. *Methyl-ethyl-phenylamine* ($NC_2H_3C_4H_5C_{12}H_5$) resembles ethyl-phenylamine, but is not, like it, coloured blue by hypochlorite of lime. *Diethylphenylamine* ($N(C_4H_5)_2C_{12}H_5$), sp. gr. 0·939; boiling point 416° Fahr. *Ethyl-nitrophenylamine* contains ($NHC_4H_5[C_{12}H_4NO_4]$). *Amyl-phenylamine* ($NHC_{10}H_{11}\,C_{12}H_5$) is soluble in ether and boils at 496°·4 Fahr. *Methyl-amyl-phenylamine* ($NC_2H_3\,C_{10}H_{11}\,C_{12}H_5$) has an agreeable odour. *Ethyl-amyl-phenylamine* ($NC_4H_5C_{10}H_{11}\,C_{12}H_5$) boils at 503°·6 Fahr. *Diamyl-phenylamine* ($N(C_{10}H_{11})_2C_{12}H_5$) boils between 527° and 536° Fahr. *Cetyl-phenylamine* ($NHC_{32}H_{33}\,C_{12}H_5$) crystallises in plates, is not soluble in water, and melts at 107°·6 Fahr. *Dicetyl-phenylamine* ($N(C_{32}H_{33})_2C_{12}H_5$) is more fusible than cetylphenylamine. *Triethyl-phenyl-ammonium*, hyd. ox. ($N(C_4H_5)_3C_{12}H_5$ OHO) forms crystalline salts. *Methyl-ethyl-amyl-phenyl-ammonium* hyd. ox. ($NC_2H_3\,C_4H_5\,C_{10}H_{11}\,C_{12}H_5$ OHO) much resembles the preceding organic base. *Ethyl-tolylamine* (NHC_4H_5, $C_{14}H_7$) is a colourless oil, sp. gr. 0·939, boiling point 422°·6 Fahr. *Diethyl-tolylamine* ($N(C_4H_5)_2\,C_{14}H_7$) boils at 444° Fahr. *Triethyltolyl-ammonium*, hyd. ox. contains ($N(C_4H_5)_3\,C_{14}H_7$ OHO).

The third general method of producing organic bases is by the decomposition of nitrogenous substances; the agents used being destructive distillation, boiling with caustic potash, and, in a few cases, oxidation; other agents, also, are used in a few special cases.

The destructive distillation of coal furnishes *pyridine* ($N(C_{10}H_5)'''$); *picoline* ($N(C_{12}H_7)'''$); *lutidine* ($N(C_{14}H_9)'''$); *collidine* ($N(C_{16}H_{11})'''$); *leucoline* ($N(C_{18}H_7)'''$); *lepidine* ($NC_{20}H_9)'''$); and *cryptidine* ($N(C_{22}H_{11})'''$). Methylamine, ethylamine, propylamine, butylamine, amylamine, pyridine, picoline, lutidine, and collidine are contained in Dippel's oil, a tarry matter obtained on destructively distilling bones. Beans also, on the application of heat furnish a base named *fabine*. Caustic potash converts the cyanates of methyl, ethyl, amyl, allyl, and phenyl into methylamine, ethylamine, amylamine, allylamine, and phenylamine respectively. The compound ureas, whose formulæ will presently be given, suffer a similar splitting up by heating with potash, ammonia being formed in addition to the bodies just mentioned. Soda-lime converts œnanthyl-aldehyd ($C_{14}H_{14}O_2$) into *tricaproylamine* ($N(C_{12}H_{13})_3$). Baryta converts creatin into *sarcosine* ($C_6H_7NO_4$). Brucine is converted by nitric acid into *cacotheline* ($C_{40}H_{22}(NO_4)_2N_2O_{10}$).

Finally, many of the organic bases already noticed, are formed during the putrefaction and fermentation of organic bodies.

The organic bases whose names and formulæ are here appended, are chiefly produced by the first general method. The cyanates of the alcohol radicals are the agents used for acting upon the ammonia, and no elimination of secondary product takes place. Moreover, they are mostly diamines and ammoniums, the organic bases hitherto described being all monamines.

Urea	$\left.\begin{matrix}(C_2O_2)''\\ H_2\\ H_2\end{matrix}\right\}N_2$
Ethyl-urea	$\left.\begin{matrix}(C_2O_2)''\\ C_4H_5\ H\\ H_2\end{matrix}\right\}N_2$
Allyl-urea	$\left.\begin{matrix}(C_2O_2)''\\ C_6H_5\ H\\ H_2\end{matrix}\right\}N_2$
Sulphallyl-urea (thiosinamine)	$\left.\begin{matrix}(C_2S_2)''\\ C_6H_5\ H\\ H_2\end{matrix}\right\}N_2$
Phenyl-urea	$\left.\begin{matrix}(C_2O_2)''\\ C_{12}H_5\ H\\ H_2\end{matrix}\right\}N_2$
Sulphophenyl-urea	$\left.\begin{matrix}(C_2S_2)''\\ C_{12}H_5\ H\\ H_2\end{matrix}\right\}N_2$
Sulphallyl-phenyl-urea	$\left.\begin{matrix}(C_2S_2)''\\ C_6H_5, C_{12}H_5\\ H_2\end{matrix}\right\}N_2$
Dimethyl-urea	$\left.\begin{matrix}(C_2O_2)''\\ (C_2H_3)_2\\ H_2\end{matrix}\right\}N_2$
Diethyl-urea	$\left.\begin{matrix}(C_2O_2)''\\ (C_4H_5)_2\\ H_2\end{matrix}\right\}N_2$
Diallyl-urea (sinapoline)	$\left.\begin{matrix}(C_2O_2)''\\ (C_6H_5)_2\\ H_2\end{matrix}\right\}N_2$
Diphenyl-urea (flavine)	$\left.\begin{matrix}(C_2O_2)''\\ (C_{12}H_5)_2\\ H_2\end{matrix}\right\}N_2$
Ethyl-allyl-urea	$\left.\begin{matrix}(C_2O_2)''\\ C_4H_5, C_6H_5\\ H_2\end{matrix}\right\}N_2$
Sulphethyl-allyl-urea	$\left.\begin{matrix}(C_2S_2)''\\ C_4H_5, C_6H_5\\ H_2\end{matrix}\right\}N_2$
Ethyl-piperyl-urea	$\left.\begin{matrix}(C_2O_2)''\\ C_4H_5\ H\\ (C_{10}H_{10})''\end{matrix}\right\}N_2$

Azophenylamine	$\left.\begin{matrix}(C_{12}H_4)''\\ H_2\\ H_2\end{matrix}\right\}N_2$
Nitrazophenylamine	$\left.\begin{matrix}C_{12}[H_3(NO)_4]''\\ H_2\\ H_2\end{matrix}\right\}N_2$
Azonaphthylamine	$\left.\begin{matrix}(C_{20}H_6)''\\ H_2\\ H_2\end{matrix}\right\}N_2$
Ethyl-picalyl-ammonium, hyd. ox.	$\left.\begin{matrix}C_4H_5(C_{12}H_7)'''N\\ H\end{matrix}\right\}O_2$
Ethyl-leucolyl-ammonium, hyd. ox.	$\left.\begin{matrix}C_4H_5(C_{18}H_7)'''N\\ H\end{matrix}\right\}O_2$
Methyl-morphyl-ammonium, hyd. ox.	$\left.\begin{matrix}C_2H_3(C_{34}H_{19}O_6)'''N\\ H\end{matrix}\right\}O_2$
Ethyl-codyl-ammonium, hyd. ox.	$\left.\begin{matrix}C_4H_5(C_{36}H_{21}O_6)'''N\\ H\end{matrix}\right\}O$
Ethyl-quinyl-ammonium, hyd. ox.	$\left.\begin{matrix}C_4H_5(C_{40}H_{24}NO_4)'''N\\ H\end{matrix}\right\}O$

Ethyl-strychnyl-ammonium, hyd. ox.	$\left.\begin{matrix}C_4H_5(C_{42}H_{22}NO_4)'''N\\ H\end{matrix}\right\}O_2$
Ethyl-nicotyl-ammonium, hyd. ox.	$\left.\begin{matrix}C_4H_5(C_{10}H_7)'''N\\ H\end{matrix}\right\}O_2$

The radicals marked in the above formulæ as teratomic (‴) are only empirically formulated, their true construction not being known. The formulæ of a few additional bodies have already been given as illustrations of diamines.

Organic phosphorous, arsenic, and antimony bases.—It has been asserted that the great characteristic of organic bases is the presence of nitrogen. The statement must, however, be received with a certain amount of qualification, inasmuch as many true organic bases have been obtained containing no nitrogen. Their constitution and chemical deportment, nevertheless, show that these bases are strict analogues of the nitrogen bases—as those hitherto described are sometimes distinctively called—and that they are, in fact, amines and ammoniums in which nitrogen is replaced by phosphorus, or arsenic, or antimony. The remarks already made respecting the nomenclature of the derivatives of NH_3 and NH_4OHO apply equally to those of the compounds under consideration, the analogues of NH_3 being of course *phosphines, arsines*, or *stibines;* and those of NH_4, *phosphoniums, arsoniums*, or *stiboniums.* They are sometimes considered as derived from PH_3, AsH_3, and SbH_3 respectively; while the analogues of the hypothetical body NH_4 are as frequently spoken of as derivatives of the still more hypothetical bodies PH_4, AsH_4, and SbH_4.

The phosphorous, arsenic, and antimony bases are at present limited to the analogues of the tertiary monamines and ammoniums, no primary or secondary phosphines, arsines, or stibines having yet been produced, nor any analogues of diamines, triamines, or tetramines.

The best process for producing the phosphorous, arsenic, and antimony bases, consists in treating the metallic compounds of the alcohol radicals with the iodides, bromides, or chlorides of phosphorus, arsenic, and antimony, respectively; the triphosphines, triarsines, and tristibines thus produced readily combine with the bromides or iodides of the alcohol radicals, and form the iodides of phosphonium, arsonium, and stibonium, respectively. The latter bodies may be converted into hydrated oxides by the usual treatment with oxide of silver. Thus:—

$$\underbrace{3(C_4H_5Zn)}_{\text{Zincethyl.}} + \underbrace{PCl_3}_{\substack{\text{Terchloride of}\\ \text{phosphorus.}}} = \underbrace{3ZnCl}_{\substack{\text{Chloride of}\\ \text{zinc.}}} + \underbrace{(C_4H_5)_3P}_{\substack{\text{Triethyl-}\\ \text{phosphine.}}}$$

and

$$\underbrace{(C_4H_5)_3P}_{\text{Triethylphosphine.}} + \underbrace{C_4H_5I}_{\substack{\text{Iodide of}\\ \text{ethyl.}}} = \underbrace{P(C_4H_5)_4I}_{\substack{\text{Iodide of tetr-ethyl-}\\ \text{phosphonium.}}}$$

and

$$P(C_4H_5)_4I + \underbrace{AgO}_{\text{Oxide of silver.}} + HO = \underbrace{\left.\begin{matrix}(C_4H_5)_4P\\ H\end{matrix}\right\}O_2}_{\substack{\text{Hyd. ox. of tetr-ethyl-}\\ \text{phosphonium.}}}$$

The general terms of the phosphorous series are:—

Trimethylphosphine	$\left.\begin{matrix}C_2H_3\\ C_2H_3\\ C_2H_3\end{matrix}\right\}P$
Triethylphosphine	$\left.\begin{matrix}C_4H_5\\ C_4H_5\\ C_4H_5\end{matrix}\right\}P$
Tetramethylphosphonium, hyd. ox.	$\left.\begin{matrix}(C_2H_3)_4\,P\\ H\end{matrix}\right\}O_2$
Trimethyl-ethylphosphonium, hyd. ox.	$\left.\begin{matrix}(C_2H_3)_3\,C_4H_5\,P\\ H\end{matrix}\right\}O_2$
Trimethyl-amylphosphonium, hyd. ox.	$\left.\begin{matrix}(C_2H_3)_3\,C_{10}H_{11}\,P\\ H\end{matrix}\right\}O_2$
Tetrethylphosphonium, hyd. ox.	$\left.\begin{matrix}(C_4H_5)_4\,P\\ H\end{matrix}\right\}O_2$
Triethyl-vinylphosphonium, hyd. ox.	$\left.\begin{matrix}(C_4H_5)_3\,C_4H_3\,P\\ H\end{matrix}\right\}O_2$

Phosphamines (R_6NSb), or diamines containing one equivalent of nitrogen replaced by phosphorus, have already been alluded to. There are a few *phosphammoniums*, $\left.\begin{matrix}R_8NP\\ H_2\end{matrix}\right\}O_4$, or diammoniums containing one equivalent of phosphorus in the place of one of nitrogen. The following are the formulæ of their hydrated oxides:—

Triethyl-ethylene-phosphammonium	$\left.\begin{matrix}(C_4H_5)_3(C_4H_4)''H_3\,NP\\ H_2\end{matrix}\right\}O_4$
Tetrethyl-ethylene-phosphammonium	$\left.\begin{matrix}(C_4H_5)_4(C_4H_4)''H_2\,NP\\ H_2\end{matrix}\right\}O_4$
Trimethyl-triethyl-ethylene-phosphammonium	$\left.\begin{matrix}(C_2H_3)_3(C_4H_5)_3(C_4H_4)''\,NP\\ H_2\end{matrix}\right\}O_4$

Each of these three bodies combines with bichloride of platinum, and forms a salt containing two equivalents of the latter substance.

The number of arsenic and antimony bases is about the same as of organic phosphorous bases. As they contain decided metals, they are conveniently classed with ORGANO-METALLIC BODIES; in basic character, however, they yield to none of the organic bases.

ORGANIC CHEMISTRY. The science of chemistry is generally studied under two distinct heads or divisions, namely, first the chemistry of inorganic or mineral matters, and the numerous substances derived from them by artificial processes; and secondly, the chemistry of compounds obtained either directly or indirectly from organised beings, vegetable or animal. The first division constitutes *inorganic chemistry*, the second *organic chemistry*. So long as the peculiar compounds recognised as organic could be obtained only through the instrumentality of that combination of conditions sometimes termed *vital force*, the above division of the science was quite definite and philosophical, but as early as the year 1828, Wöhler succeeded in producing artificially the substance *urea*, a body which had up to that time been known only as a product of the animal organism. This discovery was followed many years later by the artificial formation of acetic acid, from exposing a mixture of protochloride of carbon, water, and chlorine to sunlight, and the reduction of the chloracetic acid thus obtained into acetic acid by an amalgam of potassium. The subsequent production of methyl from acetic acid added one of the organic radicals to the list of compounds obtainable from their elements without vital action. Although little further progress was made for several years in this department of chemical research, yet the artificial production of urea and acetic acid, together with their derivatives, completely broke down the barrier between so-called still *organic* and *inorganic* bodies; the name *organic* was retained for the class of bodies to which it had previously been assigned, although now obviously no longer strictly applicable.

Whilst the term *organic chemistry* is thus deprived of its original meaning, it would still be difficult to devise a more convenient name for that portion of the science which treats of compounds that are ordinarily though not invariably derived from organised beings, hence the continuance of its use to the present day.

Classification of organic compounds.—The number of compounds included within the domain of organic chemistry has of late years become so vast, owing to the laborious researches of numerous chemists, as to render some system of classification almost absolutely necessary to enable the mind to grasp a branch of knowledge embracing such an infinite number of experimentally demonstrated facts.

Whilst on the one hand, it cannot be said that organic chemistry is not yet sufficiently developed to admit of satisfactory generalisations, on the other, it is evident that in a science which is yearly making such rapid progress, any system of classification, however satisfactory when first proposed, can scarcely be expected long to fulfil all the conditions demanded of it. Hence it would not be difficult to advance objections against the excellent system recently submitted by M. Gerhardt—a system which, notwithstanding all drawbacks, is generally admitted to be by far the best hitherto proposed. It has therefore been adopted as far as possible in the chemical articles of this Cyclopædia.

The essential portion of Gerhardt's system may be explained in very few words.

All organic compounds which have been sufficiently studied are arranged around a certain number of centres or pivots chosen from amongst the two homologous series of acids, beginning respectively with formic acid and benzoic acid. The two great divisions thus created are termed *sections*, and the families arranged about the centres are named *series*. Thus we get the following arrangement:—

FIRST SECTION.	SECOND SECTION.
Formic series.	Benzoic series.
Acetic series.	Toluic series.
Propionic series.	Xylic series.
Butyric series.	Cuminic series.
Valeric series.	Cymenic series.
Caproic series.	
Œnanthylic series.	
Caprylic series.	
Pelargonic series,	
Capric or Rutic series.	
Lauric series.	
Myristic series.	
Palmitic series.	
Stearic series.	
Cerotic series.	
Melissic series.	

Each series is subdivided into *groups:* the benzoic series for instance consists of eight groups. [BENZOIC SERIES.] Under each group will generally be found described or mentioned every individual member belonging to that group, thus under BENZOIC GROUP, one of the groups of the Benzoic series, a large number of compounds more or less intimately connected with each other, and with benzoic acid, will be found described.

Constitution of organic compounds.—One of the most difficult, but at the same time most interesting and important problems which present themselves to the chemist, is the internal arrangement or constitution of organic compounds. A child may so far investigate a watch for instance, as to discover that it consists of silver, steel, and glass, nay he might even without difficulty make his research a quantitative one, and ascertain the weights of these different materials, which enter into the composition of the instrument, but such an investigation would obviously leave the most interesting part of the history of the watch untouched; it would tell him nothing either of the arrangement of these materials or of the respective functions of the wheels, the springs, the hands, &c., the investigation of which would obviously involve a much more laborious and especially a much more intellectual inquiry. So in chemistry, the mere determination of the composition of a compound stops short of the more interesting attributes of the body—its internal arrangement and the functions performed by its several constituents. Hence the higher problem, difficult as its solution undoubtedly is, has never been lost sight of by the chemical investigator. With a view to its solution he on the one hand submits organic compounds to various processes, in order to take them to pieces; and on the other, he brings together what he conceives to be their proximate constituents, in order if possible to build up the substance he is investigating; and thus he endeavours from both the points of view thus afforded to arrive at some conclusion as to their internal constitution.

It is quite unnecessary here to notice the various views of a more general character which, with a greater or less amount of this kind of labour, have been arrived at by different chemists; it will be here sufficient to mention one such general view, which has for some years found very extensive acceptance amongst chemists. This view, which might be called the doctrine of types, regards all organic bodies as constituted in conformity with certain inorganic types,—as being cast, so to speak, in the moulds of these inorganic compounds. The four principal types are

Hydrogen Type.	Hydrochloric acid Type.	Water Type.	Ammonia Type.
$\left.\begin{array}{l}H\\H\end{array}\right\}$	$\left.\begin{array}{l}H\\Cl\end{array}\right\}$	$\left.\begin{array}{l}H\\H\end{array}\right\}O_2$	$N\left\{\begin{array}{l}H\\H\\H\end{array}\right.$

The radicals, both positive and negative, belong to the hydrogen type. The haloid compounds of these radicals are formed upon the hydrochloric acid type. The alcohols, ethers, acids, and ethereal salts belong to the water type; whilst the ammonia type includes the organic bases and the amides. In this Cyclopædia the formulæ of organic bodies are generally written in accordance with these types.

In the concluding remarks of the article ORGANOMETALLIC BODIES, an endeavour is made to show that these bodies throw considerable light upon the nature of the so-called organic radicals, and hence also upon the constitution of organic compounds in general. If the views there expressed as to the nature of organometallic bodies and their compounds be correct, the extension of those views to the organic compounds of carbon becomes inevitable. Regarded from this point of view the double atom of carbon, like that of tin, is quadratomic in perchloride of carbon and carbonic acid

$$C_2\left\{\begin{array}{l}Cl\\Cl\\Cl\\Cl\end{array}\right. \qquad\qquad C_2\left\{\begin{array}{l}O\\O\\O\\O\end{array}\right.$$

and biatomic in protochloride of carbon and carbonic oxide:

$$C_2\left\{\begin{array}{l}Cl\\Cl\end{array}\right. \qquad\qquad C_2\left\{\begin{array}{l}O\\O\end{array}\right.$$

In other words, the quadratomic stage in carbon compounds is the stage of maximum saturation, whilst the biatomic stage is one of exalted stability. If we substitute an atom of chlorine in perchloride of carbon by one of ethyl, we produce a body having the formula of trichlorhydrin:

$$C_2\left\{\begin{array}{l}C_4H_5\\Cl\\Cl\\Cl\end{array}\right.$$

If now a second atom of chlorine be substituted by one of hydrogen, we have a body exhibiting the composition of bichloride of propylene:

$$C_2\left\{\begin{array}{l}C_4H_5\\H\\Cl\\Cl\end{array}\right.$$

The treatment of this body with alcoholic potash removes hydrochloric acid, and reduces it to the protochloride type

$$\underbrace{C_2\left\{\begin{array}{l}C_4H_5\\H\\Cl\\Cl\end{array}\right.}_{\text{Bichloride of propylene.}} + KO = \underbrace{C_2\left\{\begin{array}{l}C_4H_5\\Cl\end{array}\right.}_{\text{Chloride of Allyl.}} + KCl + HO.$$

The substitution of a third atom of hydrogen for chlorine, gives the formula of chloride of propyl:

$$C_2\left\{\begin{array}{l}C_4H_5\\H\\H\\Cl\end{array}\right.$$

whilst the substitution of the last atom of chlorine by hydrogen yields hydride of propyl, or by ethyl, the so-called double radical ethyl propyl:

$$\underbrace{C_2\left\{\begin{array}{l}C_4H_5\\H\\H\\H\end{array}\right.}_{\text{Hydride of propyl.}} \qquad\qquad \underbrace{C_2\left\{\begin{array}{l}C_4H_5\\H\\H\\C_4H_5\end{array}\right.}_{\text{Ethyl-propyl.}}$$

In like manner, if we substitute an atom of oxygen in carbonic acid by ethyl, we have propionic anhydride

$$\underbrace{C_2\left\{\begin{array}{l}O\\O\\O\\O\end{array}\right.}_{\text{Carbonic acid.}} \qquad\qquad \underbrace{C_2\left\{\begin{array}{l}(C_4H_5)\\O\\O\\O\end{array}\right.}_{\text{Propionic anhydride.}}$$

A second atom substituted by hydrogen yields propionic aldehyde:

$$\underbrace{C_2\left\{\begin{array}{l}C_4H_5\\H\\O\\O\end{array}\right.}_{\text{Propionic aldehyde.}}$$

The replacement ot a third atom of oxygen by hydrogen produces propylic ether:

$$\underbrace{C_2\left\{\begin{array}{l}C_4H_5\\H\\H\\O\end{array}\right.}_{\text{Propylic ether.}}$$

Whilst the replacement of the last atom of oxygen by hydrogen, produces hydride of propyl, and by uniatomic peroxide of hydrogen, propylic alcohol:

$$\underbrace{C_2\left\{\begin{array}{l}C_4H_5\\H\\H\\H\end{array}\right.}_{\text{Hydride of propyl.}} \qquad\qquad \underbrace{C_2\left\{\begin{array}{l}C_4H_5\\H\\H\\HO_2\end{array}\right.}_{\text{Propylic alcohol.}}$$

The glycols are also constructed upon the carbonic acid type:

$$\underbrace{C_2\left\{\begin{array}{l}O\\O\\O\\O\end{array}\right.}_{\text{Carbonic acid.}} \qquad\qquad \underbrace{C_2\left\{\begin{array}{l}C_2H_3\\H\\HO_2\\HO_2\end{array}\right.}_{\text{Glycol.}}$$

And to the same type belongs also the teracid alcohol glycerin

$$C_2\left\{\begin{array}{l}C_4H_5\\HO_2\\HO_2\\HO_2\end{array}\right.$$

Under the influence of iodide of phosphorus, glycerin yields iodide of allyl:

$$\underbrace{C_2\left\{\begin{array}{l}C_4H_5\\HO_2\\HO_2\\HO_2\end{array}\right.}_{\text{Glycerin.}} \qquad\qquad \underbrace{C_2\left\{\begin{array}{l}C_4H_5\\I\end{array}\right.}_{\text{Iodide of allyl.}}$$

Here we have a reduction from the carbonic acid to the carbonic oxide type, of precisely the same nature as that which occurs when cacodylic acid is reduced to oxide of cacodyl. Allylic compounds are therefore constructed upon the carbonic oxide type:

$$\underbrace{C_2\left\{\begin{array}{l}O\\O\end{array}\right.}_{\text{Carbonic oxide.}}, \quad \underbrace{C_2\left\{\begin{array}{l}C_4H_5\\I\end{array}\right.}_{\text{Iodide of allyl.}}, \quad \underbrace{C_2\left\{\begin{array}{l}C_4H_5\\HO_2\end{array}\right.}_{\text{Allylic alcohol.}}$$

It would be easy greatly to extend this view of the constitution of organic carbon compounds, but the above examples are sufficient to indicate its general application. It is from carbonic acid, water and ammonia that nature constructs her most complex organic compounds; these inorganic substances are the essential food of plants, which thus find ready formed in the air and earth the moulds in which to cast their most complicated chemical compounds, just as animals find ready formed in their vegetable food, the plastic constituents which they employ for the construction of the various parts of their organisms.

ORGANIC COMPOUNDS, *Artificial Production of.* Under ORGANIC CHEMISTRY allusion is made to the production of urea, acetic acid, and methyl (three essentially organic compounds), by purely artificial methods, and without any assistance, direct or indirect, from vital action. The recent ingenious researches of M. Berthelot have greatly extended this branch of chemical inquiry, and have in a most important degree increased the number of bodies capable of artificial formation. The production of chloride of methyl, and the members of the olefiant gas family up to amylene ($C_{10}H_{10}$), furnishes us with the whole series of alcohols and their derivatives, from amylic alcohol downwards. Phenylic alcohol and naphthaline, both artificially produced by Berthelot, yield a host of interesting bodies; whilst phenylcarbonic acid enables us to step from the phenylic to the salicylic group, since, when treated with hyponitrous acid, it yields salicylic acid. Lastly, M. Berthelot has succeeded in artificially forming glycerin, the basis of animal and vegetable oils and fats. Grape sugar has also been added to the list; but, being produced by the contact of glycerin with putrifying animal matter, it cannot be said to be formed altogether without the agency of vitality, although the putrifying organic matter contributes none of its constituents to the new compound, and does not undergo any appreciable change in weight or appearance during the process. These substances yield such a numerous class of derivatives, that upwards of 700 distinct organic compounds can now be produced from their elements without the agency of vitality.

Amongst the most important organic compounds thus formed, the following may be mentioned :—

Name.	Formula.
Oxalic acid	$(C_2O_3, HO)_2$
Hydrocyanic acid	C_2N, H
Light carburetted hydrogen	C_2H_4
Urea	$C_2N_2H_4O_2$
Formic acid (acid of ants)	C_2HO_3, HO
Chloroform	C_2HCl_3
Acetic acid	$C_4H_3O_3, HO$
Alcohol	C_4H_5O, HO
Ether	$(C_4H_5O)_2$
Olefiant gas	C_4H_4
Acetic ether	$C_4H_5O, C_4H_3O_3$
Oil of garlic	$(C_6H_5S)_2$
Oil of mustard	C_6H_5S, C_2NS
Glycerin	$C_6H_8O_6$
Butyric acid	$C_8H_7O_3, HO$
Pine-apple flavour (butyric ether)	$C_8H_7O_3, C_4H_5O$
Succinic acid	$C_8H_4O_6, 2HO$
Valerianic acid	$C_{10}H_9O_3, HO$
Pear flavour (acetate of amyl)	$C_4H_3O_3, C_{10}H_{11}O$
Apple flavour (valerianate of amyl)	$C_{10}H_9O_3, C_{10}H_{11}O$
Lactic acid	$C_{12}H_{12}O_{12}$
Grape sugar ?	$C_{12}H_{12}O_{12}$
Caproic acid	$C_{12}H_{11}O_3, HO$
Benzole	$C_{12}H_6$
Nitrobenzole	$C_{12}H_5NO_4$
Aniline	$N(C_{12}H_5)H_2$
Phenyl alcohol (creasote)	$C_{12}H_5O, HO$
Picric acid	$C_{12}H_2(NO_4)_3O, HO$
Salicylic acid	$C_{14}H_5O_5, HO$
Salicylate of methyl (oil of wintergreen)	$C_{14}H_5O_5, C_2H_3O$
Naphthalin	$C_{20}H_8$

The artificial formation of urea, lactic acid, and caproic acid, is interesting in connection with certain functions of the animal economy. Pine-apple oil and apple oil are instances of the artificial production of the delicate flavours of fruit, whilst oil of wintergreen and nitrobenzole are like examples of the formation of esteemed perfumes. But of all the bodies hitherto thus produced, alcohol, glycerin, and sugar are undoubtedly the most deeply interesting, owing to the part they take in the nutrition of animals: they prove to us the possibility of producing, without vegetation or any vital intervention, an important part of the food of man. Should the chemist also succeed in forming artificially the nitrogenous constituents of food, without which life cannot be maintained, it would then be possible for a man planted upon a barren rock, and furnished with the necessary apparatus and inorganic materials, to support life without either animal or vegetable food. No one of these nitrogenous constituents has, however, yet been artificially produced, and the absence of all clue to their rational constitution forms at present a formidable barrier to their non-vital production.

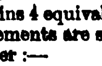
Considerations here naturally suggest themselves regarding the possibility of economically replacing natural processes by artificial ones in the formation of organic compounds. At present the possibility of doing this only attains to probability in the case of rare and exceptional products of animal and vegetable life. Thus, valerianic acid, which for a long time was extracted from the root of the *Valeriana officinalis*, could now probably be more cheaply prepared from its elements; but a still cheaper source of this acid has been in the meantime discovered, namely, the oxidation of amylic alcohol, a waste product formed in the manufacture of spirit of wine, and obtainable at such a moderate cost as to prevent, in an economical point of view, the successful production either of amylic alcohol or valerianic acid by any artificial and exclusively non-vital processes at present known. It is also highly probable that if we could produce artificially such bodies as quinine and the rare alkaloids, or alizarin, and similar powerful and valuable organic colouring matters, we should be able to compete with organic life in the formation of these bodies; nevertheless, the discovery of the processes of artificial formation would doubtless be preceded by a knowledge of methods by which such rare bodies could be produced from more abundant and consequently cheaper forms of vegetable or animal matter; and it is therefore exceedingly improbable that any purely non-vital process will be successfully and at the same time economically employed for the manufacture even of such rare and valuable vital products. Such being the economical bearings of the case with regard to the rare and exceptional educts of vitality, when we turn to consider the great staple products of the animal and vegetable kingdoms the hope of rivalling natural processes becomes faint indeed. By no process at present known could we produce sugar glycerin, or alcohol from their elements at one hundred times their present cost as obtained through the agency of vitality. But, although our present prospects of rivalling vital processes in the economical production of staple organic compounds such as those constituting the food of man are so exceedingly slight, yet it would be rash to pronounce their ultimate realisation impossible. It must be remembered that this branch of chemistry is as yet in its merest infancy, and that it has hitherto attracted the attention of few minds; and further, that many analogous substitutions of artificial for natural processes have been achieved. Thus, under certain circumstances, we find it less economical to propel our ships by the force of the wind, and our carriages by animal power, than to employ steam power for these purposes. We do not find it desirable to wait for the bleaching of our callicoes by the sun's rays; and even the grinding of corn is no longer entirely confided to wind and water power.

In such cases, where contemporaneous natural agencies have been superseded, we have almost invariably drawn upon that grand store of force collected by the plants of bygone ages, and conserved in our coalfields. It is the solar heat of a past epoch that evolves mechanical power from our steam-engines, enabling us to accomplish that which the present forces of nature alone are not capable of performing. One important element in cheap production is *time*, and it is precisely in regard to this element that we economically supersede in the above instances the contemporary resources of nature. Now time is also an important element in the natural production of food, and although it is true that the amount of labour required for the growth of a given weight of food is not considerable, yet it is nevertheless true that this weight requires a whole year for its production. By the vital process of producing food we can only have one harvest in each year. But if we were able to manufacture that food from its elements without vital agency, there would be nothing to prevent us from obtaining a harvest every week; and thus we might, in the production of food, supersede the present vital agencies of nature, as we have already done in other cases, by laying under contribution the accumulated forces of past ages, which would thus enable us to obtain in a small manufactory, and in a few days, effects which can only be otherwise realised from present natural agencies when exerted upon vast areas of land, and through considerable periods of time.

ORGANIC COMPOUNDS, CLASSIFICATION OF. [ORGANIC CHEMISTRY.]

ORGANIC COMPOUNDS, CONSTITUTION OF. [ORGANIC CHEMISTRY.]

ORGANIC RADICALS. The large number of simple atoms which generally go to form an organic substance are not bound together into one homogeneous compound, but are to a great extent arranged in groups, each group playing the part of a simple or elementary body. Such groups performing this function are termed *organic* or *compound radicals*. Thus, alcohol contains 4 equivalents of carbon, 6 of hydrogen, and 2 of oxygen, but these elements are supposed to be arranged in the alcohol in the following manner :—



$$\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}O_2$$

That is, 4 equivalents of carbon and 5 of hydrogen exist in the alcohol in the form of a compound as distinct and independent as the remaining equivalent of hydrogen; this compound of carbon and hydrogen, which is called *ethyl*, is an example of an organic radical, or of an organic group playing the part of an elementary body: for by certain chemical operations, the radical ethyl can be removed from alcohol and its place supplied by hydrogen, a kind of substitution which transforms the alcohol into water. Thus alcohol and water are related to each other, as shown in the following formulæ :—

$$\underbrace{\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}O_2}_{\text{Alcohol.}} \qquad \underbrace{\left.\begin{matrix}H\\H\end{matrix}\right\}O_2}_{\text{Water.}}$$

The simple or elementary radicals comprise, on the one hand, bodies which, like potassium, zinc, iron, and hydrogen, are electro-positive or basylous in their character; and, on the other, substances such as oxygen, sulphur, and chlorine, which are electro-negative or chlorous in their behaviour. The organic radicals admit of a precisely similar classification: some of them, such as methyl, ethyl, phenyl, &c., imitating hydrogen, zinc, or iron in their functions; whilst formyl, othyl, cyanogen, &c., resemble chlorine and sulphur in their chemical relations. Further, just as we have uniatomic, biatomic, and teratomic metals (that is, metals capable of combining with one, two, or three equivalents of other elements), so we have organic radicals which comport themselves in exactly the same manner in their modes of combination. Thus ethyl (C_4H_5) is a uniatomic, ethylene (C_4H_4'') a biatomic, and the radical of glycerin (C_6H_5''') a teratomic radical. When a radical has such a polyatomic character, its degree is represented by dashes placed after the formula, as in the cases just mentioned.

There are several families of homologous organic radicals, and they are usually distinguished by certain general formulæ. One of the most important of these families has the general formula C_nH_{n+1}, in which n represents an even number, such as 2, 4, 6, &c. The following are a few of the chief radicals belonging to this family:—

Methyl . . . . . C_2H_3 or $\left.\begin{matrix}C_2H_3\\ C_2H_3\end{matrix}\right\}$
Ethyl . . . . . . C_4H_5 or $\left.\begin{matrix}C_4H_5\\ C_4H_5\end{matrix}\right\}$
Propyl . . . . . C_6H_7 or $\left.\begin{matrix}C_6H_7\\ C_6H_7\end{matrix}\right\}$
Butyl . . . . . . C_8H_9 or $\left.\begin{matrix}C_8H_9\\ C_8H_9\end{matrix}\right\}$
Amyl . . . . . . $C_{10}H_{11}$ or $\left.\begin{matrix}C_{10}H_{11}\\ C_{10}H_{11}\end{matrix}\right\}$

A second family has the general formula C_nH_{n-7}. None of its members are yet known in a separate state, but analogy admits of no doubt as to their existence in certain well-known organic compounds. The following are some of the most important members of this family:—

Phenyl . . . . . $C_{12}H_5$ or $\left.\begin{matrix}C_{12}H_5\\ C_{12}H_5\end{matrix}\right\}$
Toluenyl . . . . . $C_{14}H_7$ or $\left.\begin{matrix}C_{14}H_7\\ C_{14}H_7\end{matrix}\right\}$
Cumenyl . . . . . $C_{18}H_{11}$ or $\left.\begin{matrix}C_{18}H_{11}\\ C_{18}H_{11}\end{matrix}\right\}$
Cymenyl . . . . . $C_{20}H_{13}$ or $\left.\begin{matrix}C_{20}H_{13}\\ C_{20}H_{13}\end{matrix}\right\}$

A third family has the general formula C_nH_{n-1}. It has hitherto been very little explored, and the only member known with certainty is—

Allyl . . . . . . , C_6H_5 or $\left.\begin{matrix}C_6H_5\\ C_6H_5\end{matrix}\right\}$

All the families above described contain only uniatomic radicals, but by the abstraction of one equivalent of hydrogen they all yield corresponding biatomic radicals. Thus:—

$$\underbrace{C_4H_5}_{\text{Ethyl.}} - H = \underbrace{C_4H_4''}_{\text{Ethylene.}}$$

The following are the chief biatomic radicals of the form C_nH_n:—

Methylene . . . . C_2H_2''
Ethylene . . . . C_4H_4''
Propylene . . . . C_6H_6''
Butylene . . . . C_8H_8''
Amylene . . . . $C_{10}H_{10}''$

With the exception of methylene, all these biatomic radicals can be readily obtained in a separate state.

A family of teratomic radicals of the form C_nH_{n-1} appears also to exist, although up to the present time only one member is known, and that only in combination. Glycerin contains this radical, which is termed—

Glyceryl . . . . C_6H_5'''

All the radicals hitherto considered are *positive* or *basylous* radicals, but by the exchange of two equivalents of hydrogen for two of oxygen they are all transformed into *negative* or *chlorous* radicals; thus, the positive radical ethyl, minus two atoms of hydrogen, plus two of oxygen, passes into the negative radical othyl or acetyl:—

$$\underbrace{C_4H_5}_{\text{Ethyl.}} + O_2 - H_2 = \underbrace{C_4H_3O_2}_{\text{Othyl.}}$$

Hitherto uniatomic negative radicals alone have been clearly established, but there can be no doubt that biatomic and teratomic positive radicals, by a similar substitution of oxygen for hydrogen, pass into corresponding negative radicals of the same polyatomic character.

The following are some of the most important uniatomic negative radicals:—

1. Of the form $C_nH_{n-1}O_2$. Derivatives from C_nH_{n+1}.

Formyl . . . . . C_2HO_2 or $\left.\begin{matrix}C_2HO_2\\ C_2HO_2\end{matrix}\right\}$
Othyl or acetyl . . . . $C_4H_3O_2$ or $\left.\begin{matrix}C_4H_3O_2\\ C_4H_3O_2\end{matrix}\right\}$
Propionyl . . . . $C_6H_5O_2$ or $\left.\begin{matrix}C_6H_5O_2\\ C_6H_5O_2\end{matrix}\right\}$
Butyryl . . . . . $C_8H_7O_2$ or $\left.\begin{matrix}C_8H_7O_2\\ C_8H_7O_2\end{matrix}\right\}$

2. Of the form $C_nH_{n-9}O_2$. Derivatives from C_nH_{n-7}.

Benzöyl . . . . $C_{14}H_5O_2$ or $\left.\begin{matrix}C_{14}H_5O_2\\ C_{14}H_5O_2\end{matrix}\right\}$
Toluyl . . . . . $C_{16}H_7O_2$ or $\left.\begin{matrix}C_{16}H_7O_2\\ C_{16}H_7O_2\end{matrix}\right\}$
Cumyl . . . . $C_{20}H_{11}O_2$ or $\left.\begin{matrix}C_{20}H_{11}O_2\\ C_{20}H_{11}O_2\end{matrix}\right\}$

3. Of the form $C_nH_{n-3}O_2$. Derivatives from C_nH_{n-1}.

Acryl . . . . . . $C_6H_3O_2$ or $\left.\begin{matrix}C_6H_3O_2\\ C_6H_3O_2\end{matrix}\right\}$

In addition to the bodies above described, another class, termed *double radicals*, are known to chemists. These are formed by the union of any two single positive radicals, or of a positive with a negative radical. No double negative radical has yet been obtained. The following instances will suffice to indicate the composition of the double radicals:—

Ethyl-amyl . . . . $\left.\begin{matrix}C_4H_5\\ C_{10}H_{11}\end{matrix}\right\}$
Acetone or methyl-othyl . . . . $\left.\begin{matrix}C_4H_3O_2\\ C_2H_3\end{matrix}\right\}$

The double radicals containing both a positive and a negative constituent are better known under the name of ketones. [KETONES.]

It has been stated above that of the single radicals, those belonging to the positive division only have been isolated, and of these the members of the family C_nH_{n-7} are entirely unknown in a separate state. The two methods admitting of general application for the isolation of the positive radicals, are the following:—

1. The action of zinc, potassium, or sodium, upon the iodides of the radicals. Thus, for the isolation of ethyl:—

$$\underbrace{2\left.\begin{matrix}C_4H_5\\ I\end{matrix}\right\}}_{\text{Iodide of Ethyl.}} + Zn_2 = 2ZnI + \underbrace{\left.\begin{matrix}C_4H_5\\ C_4H_5\end{matrix}\right\}}_{\text{Ethyl.}}$$

2. By the action of nascent oxygen, evolved from the positive pole of a voltaic battery, upon the fatty acids. Thus, for the isolation of methyl:—

$$\underbrace{2\left.\begin{matrix}C_4H_3O_2\\ H\end{matrix}\right\}O_2}_{\text{Acetic acid.}} + O_2 = 2\underbrace{C_2O_4}_{\text{Carbonic acid.}} + 2HO + \underbrace{\left.\begin{matrix}C_2H_3\\ C_2H_3\end{matrix}\right\}}_{\text{Methyl.}}$$

ORGANOMETALLIC BODIES. A numerous family of chemical compounds in which compound organic radicals, such as methyl, ethyl, &c., are united with metals, in a manner analogous to that in which the elementary radical chlorine is combined with sodium and zinc, in sea-salt and chloride of zinc. If, for instance, in chloride of zinc we replace the chlorine by ethyl, we produce one of the bodies belonging to this family, namely, zincethyl:—

$$\underbrace{ZnCl}_{\text{Chloride of zinc.}} \qquad \underbrace{Zn(C_4H_5)}_{\text{Zincethyl.}}$$

Although organometallic bodies as a distinct class of organic compounds are, with one exception, the creation of the last ten years, yet the derivatives of these bodies have been known for a much longer period. From the time that an organic acid was first united with a metallic base these organic compounds containing metals date their existence. It is true that such compounds containing a metallic constituent have not been regarded from this point of view, but a little consideration will serve to show that they stand in the same relation to organometallic bodies, in the strict sense of the term, as the alcohol radicals occupy with regard to the ethers, alcohols, acids, and numerous other families derived from these radicals.

Thus, zincethyl yields by oxidation ethylate of zinc—

$$\underbrace{ZnC_4H_5}_{\text{Zincethyl.}} + O_2 = \underbrace{ZnO,\ C_4H_5O}_{\text{Ethylate of zinc,}}$$

a body which, although unknown until formed by this re-action, has undoubted and well-known analogies in the ethylates of potash and soda.

By suitable processes of oxidation, ethylate of zinc may be converted into acetate of zinc:—

$$ZnO,\ C_4H_5O + 4O = \left.\begin{matrix}C_4H_3O_2\\ Zn\end{matrix}\right\}O_2 + \left.\begin{matrix}H\\ H\end{matrix}\right\}O_2$$

Again, potassium-methyl and sodium-methyl under the influence of carbonic acid yield the acetates of potash and soda:—

$$\underbrace{NaC_2H_3}_{\text{Sodium methyl.}} + \underbrace{C_2O_4}_{\text{Carbonic acid.}} = \underbrace{\left.\begin{matrix}C_4H_3O_2\\ Na\end{matrix}\right\}O_2}_{\text{Acetate of soda.}}$$

Such being the relations between organometallic bodies in the usual acceptation of the term, and that far more numerous class of derivatives to which the same name might without impropriety be applied, it is scarcely necessary to remark that this article will be confined to the consideration of organometallic bodies in the usual and more restricted sense of the term.

FORMATION OF ORGANOMETALLIC BODIES.

Organometallic bodies admit of being formed by a great variety of processes, which, however, with very few exceptions, admit of being grouped under four heads.

1. *Formation by the union of an organic radical in statu nascenti with the metal.*—Organic compounds containing zinc, cadmium, magnesium, aluminium, glucinum, tin, and mercury, are produced by this method.

Zincethyl, which may be regarded as the type of organo-zinc compounds, is obtained by digesting a mixture of equal volumes of iodide of ethyl and ether with granulated zinc in a strong glass or copper vessel, at a temperature of about 260° Fahr., for several hours. Subsequent distillation gives a mixture of zinc-ethyl and ether, from which the former is obtained pure by rectification. The re-action may be thus expressed—

$$\underbrace{2C_4H_5I}_{\text{Iodide of ethyl.}} + Zn_4 = \underbrace{\left.\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right\}Zn_2}_{\text{Zincethyl.}} + 2\left.\begin{matrix}Zn\\I\end{matrix}\right\}$$

Zincmethyl and *zincamyl* are produced by analogous processes.

The same method of formation yields cadmium-ethyl, when iodide of ethyl is digested with cadmium at a temperature of from 212° to 280°.

$$\underbrace{2\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}} + Cd_4 = 2CdI + \underbrace{2(C_4H_5Cd)}_{\text{Cadmium-ethyl.}}$$

Treated with iodide of ethyl, magnesium gives *magnesium-ethyl,* the reaction commencing briskly at ordinary temperatures, but requiring a heat of 248° to 266° for its completion.

$$4Mg + 2\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\} = Mg_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right. + 2\left.\begin{matrix}Mg\\I\end{matrix}\right\}$$

The homologous re-action with iodide of methyl appears also to yield *magnesium-methyl.*

$$4Mg + 2\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\} = Mg_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right. + 2\left.\begin{matrix}Mg\\I\end{matrix}\right\}$$

Similarly treated, aluminium yields, at temperatures from 212° Fahr. to 266° F., *Aluminium-ethyl* and *Aluminium-methyl.*

$$3\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\} + Al_4 = \left(Al_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right. + Al_2\left\{\begin{matrix}I\\I\\I\end{matrix}\right.\right)$$

$$3\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\} + Al_4 = \left(Al_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\end{matrix}\right. + Al_2\left\{\begin{matrix}I\\I\\I\end{matrix}\right.\right)$$

Double compounds of aluminium-ethyl and aluminium-methyl, with the iodide of aluminium, are here formed, and the former bodies have not yet been obtained with certainty free from iodide of aluminium.

Glucinium-ethyl appears also to be formed under similar circumstances, although its existence has not yet been confirmed by analysis.

Compounds of tin with alcohol radicals.—Although these organometallic bodies can be obtained by other processes, the general method we are now considering is doubtless the most convenient mode of producing the most important of them, as well as their iodine compounds.

Tin is capable of forming three distinct classes of binary inorganic compounds, which may be represented by the following general formulæ :—

$$Sn_2\left\{\begin{matrix}R\\R\end{matrix}\right. \qquad Sn_2\left\{\begin{matrix}R\\R\\R\end{matrix}\right. \qquad Sn_2\left\{\begin{matrix}R\\R\\R\\R\end{matrix}\right.$$

In these and the following formulæ R represents any radical positive or negative, R + a positive organic radical, and R— a negative inorganic radical.

This threefold atomic character of the metal tin renders the results of its action upon the iodides of the alcohol radicals considerably less simple than those which we have hitherto considered. Without taking into account compounds to which a still more complex constitution has been assigned, the existence of the following series of organometallic bodies containing tin has been established :—

$$(1)\quad Sn_2\left\{\begin{matrix}R+\\R+\end{matrix}\right.$$

$$(2)\quad Sn_2\left\{\begin{matrix}R+\\R+\\R+\end{matrix}\right.$$

$$(3)\quad Sn_2\left\{\begin{matrix}R+\\R+\\R-\end{matrix}\right.$$

$$(4)\quad Sn_2\left\{\begin{matrix}R+\\R+\\R+\\R+\end{matrix}\right.$$

$$(5)\quad Sn_2\left\{\begin{matrix}R+\\R+\\R+\\R-\end{matrix}\right.$$

$$(6)\quad Sn_2\left\{\begin{matrix}R+\\R+\\R-\\R-\end{matrix}\right.$$

The second and fourth of these series have not yet been produced by the method we are now considering.

FIRST SERIES.

Stannous ethide, or *Stanethyl* ($Sn_2(C_4H_5)_2$), is formed in small quantity by the action of heat upon a mixture of iodide of ethyl and tin—

$$\underbrace{2\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}} + Sn_4 = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Stannous ethide.}} + 2SnI$$

Stannous methide, or *Stanmethyl* ($Sn_2(C_2H_3)_2$), is doubtless formed under similar conditions.

THIRD SERIES.

The third series of stann-organic compounds are formed by the following re-actions :—

$$\underbrace{2\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} + Sn_3 = \underbrace{Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\I\end{matrix}\right.}_{\text{Dimethiodide of tin.}} + SnI$$

$$\underbrace{2\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}} + Sn_3 = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\end{matrix}\right.}_{\text{Diethiodide of tin.}} + SnI$$

FIFTH SERIES.

The following chemical changes express the mode of formation of compounds belonging to this series :—

$$\underbrace{3\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} + Sn_4 = \underbrace{Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\\I\end{matrix}\right.}_{\text{Trimethiodide of tin.}} + 2SnI$$

$$\underbrace{3\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}} + Sn_4 = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\I\end{matrix}\right.}_{\text{Triethiodide of tin.}} + 2SnI$$

SIXTH SERIES.

The most abundant products of the action of tin upon the iodides of the alcohol radicals belong to this series. Indeed, if the action be produced by light instead of heat, this series of bodies is formed almost to the complete exclusion of the others. It is necessary, however, to remark, that the materials exposed to light should be completely excluded from atmospheric oxygen, otherwise the liquid assumes an orange colour, and the action is so effectually arrested that an exposure for several months to sunlight, concentrated by a parabolic mirror, will scarcely produce any appreciable change. The following re-actions explain the formation of bodies belonging to this series :—

$$\underbrace{2\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} + Sn_2 = \underbrace{Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\I\\I\end{matrix}\right.}_{\text{Stannic dimethiodide.}}$$

$$\underbrace{2\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}} + Sn_2 = \underbrace{Sn\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\\I\end{matrix}\right.}_{\text{Stannic diethiodide of tin.}}$$

Mercury compounds.—The re-action of mercury upon the iodides of the alcohol radicals gives rise to two classes of organic compounds, the general formulæ of which may be thus written :—

$$1.\quad Hg\left\{\begin{matrix}R+\\R-\end{matrix}\right.$$

$$2.\quad Hg\left\{\begin{matrix}R+\\R+\end{matrix}\right.$$

The first series only of these bodies can be produced by the general mode of formation now being considered, but the members of the second series are readily obtained by the action of an organo-zinc compound upon those of the first. For the production of the first series of these bodies the action of light is essential, no elevation of temperature being capable of producing the chemical change. The following equations sufficiently exhibit the nature of the re-action :—

$$\underbrace{\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} + Hg = \underbrace{Hg\left\{\begin{matrix}C_2H_3\\I\end{matrix}\right.}_{\text{Methiodide of mercury.}}$$

$$\underbrace{\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}} + Hg = \underbrace{Hg\left\{\begin{matrix}C_4H_5\\I\end{matrix}\right.}_{\text{Ethiodide of mercury.}}$$

For the production of the methyl compound bright sunlight may be employed, but the re-action for the ethyl body must be conducted in diffused daylight only, otherwise no organometallic body will be produced, the ethyl being eliminated chiefly as such, but partly also as hydride of ethyl and ethylene.

In addition to these organometallic bodies, compounds containing arsenic and antimony can also be produced by this general mode of formation, but they are obtained with greater facility by the second method, which will now be described.

2. *Formation of organometallic bodies by the action of the respective metals alloyed with potassium or sodium upon the iodides of the alcohol radicals.*—The principles involved in this general mode of production are essentially similar to those in the first method, but there is here less tendency to form compounds containing negative as well as positive radicals. This method, although not capable of such general application, is more especially adapted for the formation of the organic compounds of the polyatomic metals. The simultaneous production of an organo-potassium or -sodium compound is not here to be feared, so long as the iodide of the alcohol radical is present in excess, because such compounds cannot exist in the presence of the iodides of the alcohol radicals.

This mode of formation will be sufficiently illustrated by the following re-actions :—

Arsenic Compounds.

$$Na_2As + \underbrace{2\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} = \underbrace{As\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Cacodyl.}} + 2NaI$$

$$Na_3As + \underbrace{3\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} = \underbrace{As\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Trimethylarsine}} + 3NaI$$

$$Na_3As + \underbrace{4\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} = \underbrace{As\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\\C_2H_3\\I\end{matrix}\right.}_{\text{Iodide of tetramethylarsonium.}} + 3NaI$$

Antimony Compounds.

$$Na_3Sb + \underbrace{3\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} = \underbrace{Sb\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Trimethylstibine.}} + 3NaI$$

$$Na_3Sb + \underbrace{4\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} = \underbrace{Sb\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\\C_2H_3\\I\end{matrix}\right.}_{\text{Iodide of tetramethylstibonium.}} + 3NaI$$

Tin Compounds.

$$2NaSn + \underbrace{2C_2H_3I}_{\text{Iodide of methyl.}} = \underbrace{Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Methide of tin or stannous methide.}} + 2NaI$$

$$Na_3Sn_2 + \underbrace{3\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} = \underbrace{Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Sequimethide of tin.}} + 3NaI$$

$$2Na_2Sn + \underbrace{4\left.\begin{matrix}C_2H_3\\I\end{matrix}\right\}}_{\text{Iodide of methyl.}} = \underbrace{Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Bimethide of tin, or stannic methide.}} + 4NaI$$

Lead Compounds.

$$Na_3Pb_2 + \underbrace{3\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}} = \underbrace{Pb_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Sesquiethide of lead.}} + 3NaI$$

Bismuth Compounds.

$$Na_3Bi + \underbrace{3C_4H_5I}_{\text{Iodine of ethyl.}} = \underbrace{Bi\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Bistriethyl.}} + 3NaI$$

Tellurium Compounds.

Organo-tellurium compounds are formed by a modification of this method, which consists in distilling telluride of potassium with sulphovinate of potash and its homologues.

$$\underbrace{2(C_2H_3O\,SO_3,\ KO\,SO_3)}_{\text{Sulphomethylateof potash.}} + 2KTe = \underbrace{Te_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Tellurium-methyl.}} + 4KO\,SO_3$$

$$\underbrace{2(C_4H_5O\,SO_3,\ KO\,SO_3)}_{\text{Sulphovinate of potash.}} + 2KTe = \underbrace{Te_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Tellurium-ethyl.}} + 4KO\,SO_3$$

$$\underbrace{2(C_{10}H_{11}O\,SO_3,\ KO\,SO_3)}_{\text{Sulphamylate of potash.}} + 2KTe = \underbrace{Te_2\left\{\begin{matrix}C_{10}H_{11}\\C_{10}H_{11}\end{matrix}\right.}_{\text{Tellurium-amyl.}} + 4KO\,SO_3$$

3. *Formation of organometallic bodies by the action of the zinc compounds of the organic radicals upon the haloid compounds, either of the metals themselves or of their organo-derivatives.*—For the production of organometallic bodies containing less positive metals than zinc, this method is perhaps not only the most convenient but also of the most general application. Organo-compounds containing mercury, tin, lead, antimony, and arsenic, have in this way been produced, but it has failed when applied to the haloid compounds of copper, silver, and platinum, for although these bodies are violently acted upon, the organic radical does not unite with the metals.

The following leading reactions represent the present state of our knowledge with regard to this method of formation :—

Tin Compounds.

$$\underbrace{2Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + 2SnCl_2 = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Stannic ethide.}} + 4ZnCl$$

$$\underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\\I\end{matrix}\right.}_{\text{Ethiodide of tin.}} = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Stannic ethide.}} + 2ZnI$$

$$\underbrace{Zn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Zincmethyl.}} + \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\\I\end{matrix}\right.}_{\text{Ethiodide of tin.}} = \underbrace{Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Stannic ethylo-methide.}} + 2ZnI$$

Mercury Compounds.

$$\underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + HgCl_2 = \underbrace{Hg\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Mercuric ethide.}} + 2ZnCl$$

$$\underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Mercuric ethide.}} + 2Hg\left\{\begin{matrix}Cl\\Cl\end{matrix}\right. = \underbrace{2Hg\left\{\begin{matrix}C_4H_5\\Cl\end{matrix}\right.}_{\text{Mercuric ethochloride.}} + 2ZnCl$$

$$\underbrace{Zn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Zincmethyl.}} + 2HgCl_2 = \underbrace{2Hg\left\{\begin{matrix}C_2H_3\\Cl\end{matrix}\right.}_{\text{Mercuric methochloride.}} + 2ZnCl$$

Mercurous ethide (HgC_4H_5) and *mercurous methide* (HgC_2H_3) have not yet been obtained, either by this or any other process. The instability of mercurous compounds, as seen in the inorganic oxide and iodide, is brought to a climax in organic mercurous compounds, they are instantly transformed into metallic mercury and the more stable organo-mercuric compounds. Thus when zincethyl acts upon mercurous chloride the following change results:

$$Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right. + 2HgCl = Hg\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right. + Hg + 2ZnCl$$

Lead Compounds.

In this series, the following is the only reaction which has hitherto been effected by the method which we are now considering :—

$$\underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + 2PbCl = \underbrace{Pb\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Plumbic ethide.}} + Pb + 2ZnCl$$

4. *Formation of organometallic bodies by the displacement of a metal in organic combination by another and more positive metal.*—This mode of producing organometallic bodies has hitherto been applied only to the formation of sodium and potassium compounds, or rather double

compounds of these bodies with zincethyl, according to the following reactions:—

$$\underbrace{3Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + Na_2 = \underbrace{\left(2Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right. + Na_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.\right)}_{\text{Double compound of sodiumethyl and zincethyl.}} + Zn_2$$

$$\underbrace{3Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + K_2 = \underbrace{\left(2Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right. + K_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.\right)}_{\text{Potassiumethyl and zincethyl.}} + Zn_2$$

Sodium also displaces mercury from mercuric ethide; sodiumethyl appears to be formed, but the exact nature of the reaction has not been ascertained.

PROPERTIES OF ORGANOMETALLIC BODIES.

The organometallic compounds as a class are distinguished for the extraordinary energy of their affinities. With certain exceptions, presently to be noticed, their disposition to unite with negative elements increases with the positive character of the metal, and with the smallness of the atomic weight of the alcohol radical. Thus organo-potassium and sodium compounds possess more chemical energy than those of zinc, whilst the latter are more active than the organo-compounds of arsenic, antimony, tin, lead, &c. Again, in the family belonging to each metal, the methylic compounds are more energetic than the ethylic ones, whilst the last greatly surpass the amyl compounds in this respect. But whilst these general principles govern the chemical energy of organometallic bodies, their effect appears to be modified by the degree of saturation in which the metal exists. Although this circumstance has hitherto received only very partial elucidation, yet we have evidence of its existence in the case of the organo-tin compounds. Both stannous ethide and stannous methide combine directly with atmospheric oxygen, and the union takes place with tolerable rapidity, but neither stannic ethide nor stannic methide are in the least degree acted upon by free oxygen at ordinary temperatures; even iodine acts upon them with difficulty. This diminution of chemical energy in organostannic compounds cannot be ascribed to the mere influence of the additional weight of hydrocarbon which they contain, since stannous amylide readily unites with free oxygen at ordinary temperatures, although the single molecule of amyl which it contains is considerably heavier than the double atom of either methyl or ethyl contained in the organostannic compounds just cited.

Organometallic compounds in a state of partial saturation play the part of compound radicals. They are uniatomic, biatomic, teratomic, or quadratomic, according to the number of molecules requisite to complete their saturation. On the other hand, organometallic bodies in a state of saturation never perform radical functions, they never undergo chemical change without decomposition: thus zincethyl, stannic ethide, mercuric ethide, and plumbic ethide all give substitution products when they are chemically acted upon.

The description of the special properties of the organometallic bodies may be conveniently commenced with the most positive of the class, namely:—

Organo-potassium and sodium compounds.—These bodies have not yet been isolated, they are known only in combination with the corresponding zinc compounds. The double compound of sodiumethyl and zincethyl is the only one which has hitherto been submitted to analysis. Its formula is

$$Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right. + NaC_4H_5$$

This compound first separates from its solution in zincethyl as a transparent fluid, which, after some time, solidifies to a mass of large tubular crystals, which fuse at 27° C., but when once fused, remain fluid at several degrees below that point. On the application of a moderate heat, gases are evolved, and a mixture of sodium and zinc without carbon is left behind. The double compound decomposes water with great violence, forming hydride of ethyl and hydrated oxides of zinc and sodium. The behaviour with negative elements has not yet been studied. Its most interesting reaction consists in the absorption of carbonic acid, which it transforms into propionic acid. The sodiumethyl alone takes part in this reaction.

$$\underbrace{NaC_4H_5}_{\text{Sodiumethyl.}} + C_2O_4 = \underbrace{\left.\begin{matrix}C_6H_5O_2\\Na\end{matrix}\right\}O_2}_{\text{Propionate of soda.}}$$

Similar double compounds, containing *sodiummethyl*, as well as the potassium compounds of ethyl and methyl, have been formed. They have not yet been completely investigated, but it is believed that their composition and properties are perfectly analogous to those of sodiumethyl.

No compound of any of these bodies with a negative element has been obtained. Their action upon carbonic acid proves that they possess a still higher reducing power than the corresponding organo-zinc compounds, and they will therefore doubtless prove valuable agents for the substitution of positive groups for negative elements in cases where organo-zinc compounds fail to produce the desired effect.

Sodiumethyl decomposes the iodides of the alcohol radicals in the cold, with the formation of iodide of sodium.

$$\underbrace{NaC_4H_5}_{\text{Sodiumethyl.}} + \underbrace{\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}} = NaI + \underbrace{\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}}_{\text{Hydride of ethyl.}} + \underbrace{C_4H_4}_{\text{Ethylene.}}$$

On this account, these bodies can only be prepared by method No 4.

Organo-magnesium compounds.—The compounds containing ethyl and methyl only have hitherto been examined, and the former alone submitted to analysis. These bodies possess a close similarity to organo-zinc compounds. They are very volatile colourless liquids possessing a powerful alliaceous odour, are spontaneously inflammable, and decompose water with violence. They do not readily decompose the iodides of the alcohol radicals, and can hence be prepared by the method No. 1. No compound of these bodies with negative elements has yet been produced. They are in the condition of chemical saturation. Further details of their properties are wanting.

Organo-aluminium compounds.—Like the organo-compounds of the alkaline metals, the aluminium compounds have not yet with certainty been isolated; they are only known in combination with iodide of aluminium, and the composition of the ethyl body only has been fixed by analysis. Its formula is

$$Al_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right. + Al_2\left\{\begin{matrix}I\\I\\I\end{matrix}\right.$$

These double compounds possess great chemical energy; they are spontaneously inflammable volatile liquids, which decompose water with explosive violence. They are attacked by zincethyl, forming iodide of zinc and very inflammable liquids, which are believed to be the pure organo-aluminium compounds. They appear to be chemically saturated bodies, and therefore incapable of direct combination. Further details are wanting.

Organo-glucinum compound.—The metal glucinum acts upon iodide ethyl, forming a liquid which rapidly decomposes water, and which is believed to be analogous to the double iodethide of aluminium above described, but it has not been further examined.

Organo-zinc compounds.—Three of these are more or less completely known, namely:—

Zincmethyl . . . . . . $Zn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.$

Zincethyl . . . . . . $Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.$

Zincamyl . . . . . . $Zn_2\left\{\begin{matrix}C_{10}H_{11}\\C_{10}H_{11}\end{matrix}\right.$

They are colourless, transparent, mobile, volatile, and odorous liquids, composed of 4 gaseous volumes of the hydrocarbon radical, and 2 volumes of zinc vapour, the six volumes condensed to 4. The methyl and ethyl compounds are spontaneously inflammable, burning with a greenish-blue flame. All three are saturated compounds, incapable of direct combination. In contact with water they are instantly decomposed with the formation of oxide of zinc, and hydride of the organic radical. Thus zincethyl suffers the following decomposition:—

$$\underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + \left.\begin{matrix}H\\H\end{matrix}\right\}O_2 = \left.\begin{matrix}Zn\\Zn\end{matrix}\right\}O_2 + \underbrace{2\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}}_{\text{Hydride of ethyl.}}$$

Gradually treated with oxygen, so as to avoid too violent action, they form the respective zinc alcohols:—

$$\underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + O_4 = \underbrace{2\left.\begin{matrix}C_4H_5\\Zn\end{matrix}\right\}O_2}_{\text{Ethylate of zinc.}}$$

The action of iodine upon organo-zinc compounds consists in the transformation of both their constituents into iodides:—

$$\underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + I_4 = 2ZnI + \underbrace{2\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}}$$

Organo-zinc compounds behave in a manner exactly analogous in contact with the other halogens.

Reactions like the foregoing point to the applicability of organo-zinc compounds for effecting the substitution of positive groups for negative elements in compound bodies; an application which has not failed to attract the notice of chemists. In addition to re-actions of this class, given above, as examples of the formation of organometallic bodies by the third method, the following have been realised:—

Binoxide of Nitrogen.

$$\underbrace{2(N_2O_4)}_{\text{Binoxide of nitrogen.}} + \underbrace{Zn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Zincmethyl.}} = \underbrace{2\left.\begin{matrix}N_2C_2H_3O_2\\Zn\end{matrix}\right\}O_2}_{\text{Dinitromethylate of zinc.}}$$

$$\underbrace{2(N_2O_4)}_{\text{Binoxide of nitrogen.}} + Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right. = \underbrace{2\left.\begin{matrix}N_2C_4H_5O_2\\Zn\end{matrix}\right\}O_2}_{\text{Dinitroethylate of zinc.}}$$

It will be perceived that this re-action is the exact analogue of the one already mentioned in connection with organo-sodium and potassium compounds, in which carbonic acid, treated with sodium methyl and sodium ethyl forms acetic and propionic acids: in fact, dinitromethylic and dinitroethylic acids may be regarded as the analogues of acetic and propionic acids respectively; the nitrogen, here sustaining a biatomic character, replacing an equivalent amount of carbon.

Sulphurous Acid.

$$\underbrace{4(SO_2)}_{\text{Sulphurous acid.}} + \underbrace{Zn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Zincmethyl.}} = \underbrace{2\left.\begin{matrix}S_2C_2H_3O_2\\Zn\end{matrix}\right\}O_2}_{\text{Methylodithionate of zinc.}}$$

$$\underbrace{6(SO_2)}_{\text{Sulphurous acid.}} + \underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} = \underbrace{2\left.\begin{matrix}S_3C_4H_5O_4\\Zn\end{matrix}\right\}O_2}_{\text{Ethylotrithionate of zinc.}}$$

Chloride of Phosphorus.

$$\underbrace{2(PCl_3)}_{\text{Terchloride of phosphorus.}} + \underbrace{3Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} = \underbrace{2P\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Triethylphosphine.}} + 6ZnCl$$

There is no apparent obstacle to this reaction being pushed to its extreme limit in the case of pentatomic bodies, such as phosphorus, arsenic, or antimony. Mr. Buckton has recently attempted this in the case of antimony, but although evidence of the existence of a pentethide of antimony was obtained, the body could not be isolated and its composition satisfactorily fixed. The greater stability of the triatomic compounds of these bodies will probably present considerable difficulty in the way of obtaining pentatomic compounds of an exclusively positive character, such bodies being doubtless easily resolved into the more stable groupings represented in the following equation:

$$\underbrace{Sb\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Pentethide of antimony.}} = \underbrace{Sb\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Triethylstibine.}} + \underbrace{\left.\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right\}}_{\text{Ethyl}}$$

Whilst on the one hand organo-zinc compounds are thus capable of effecting the substitution of their positive organic group for negative elements, on the other they can in certain cases replace hydrogen by zinc, forming, with ammonia and its homologues, for instance, a series of zincamides. In this direction the following reactions, amongst others, have been recorded.

$$\underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + \underbrace{2N\left\{\begin{matrix}H\\H\\H\end{matrix}\right.}_{\text{Ammonia.}} = \underbrace{2N\left\{\begin{matrix}H\\H\\Zn\end{matrix}\right.}_{\text{Zincamide.}} + \underbrace{2\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}}_{\text{Hydride of ethyl.}}$$

$$\underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + \underbrace{2N\left\{\begin{matrix}C_4H_5\\C_4H_5\\H\end{matrix}\right.}_{\text{Diethylamine.}} = \underbrace{2N\left\{\begin{matrix}C_4H_5\\C_4H_5\\Zn\end{matrix}\right.}_{\text{Diethylzincamide.}} + \underbrace{2\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}}_{\text{Hydride of ethyl.}}$$

$$\underbrace{Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Zincethyl.}} + \underbrace{N_2\left\{\begin{matrix}C_4O_4''\\H_2\\H_2\end{matrix}\right.}_{\text{Oxamide.}} = \underbrace{N_2\left\{\begin{matrix}C_4O_4''\\H_2\\Zn_2\end{matrix}\right.}_{\text{Zincoximide.}} + \underbrace{2\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}}_{\text{Hydride of ethyl.}}$$

The members of the zinc series unite with neutral salts to form compounds which have been but little examined. The following however are known:

Dinitromethylate of zinc and zincmethyl . $2\left.\begin{matrix}N_2C_2H_3O_2\\Zn\end{matrix}\right\}O_2 + Zn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.$

Dinitroethylate of zinc and zincethyl . . $2\left.\begin{matrix}N_2C_4H_5O_2\\Zn\end{matrix}\right\}O_2 + Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.$

Finally, it has been observed that zincmethyl, when generated in contact with methylic or vinic ether, combines with these bodies, forming

Methylate of zincmethyl . . $2\left(Zn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.\right) + \left.\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right\}O_2$

Ethylate of zincethyl . . . $2\left(Zn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.\right) + \left.\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right\}O_2$

Cadmium Series.—Only one member of this series is known, and that very imperfectly. So far as its properties have been made out, they appear to be perfectly analogous to those of the zinc series.

Tin Series.—A large number of organometallic bodies containing tin have been described. The existence of the following may be considered as clearly established.

a. Stannous Compounds.

Stannous methide or stanmethyl . . . $Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.$

Stannous ethide or stanethyl . . . . $Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.$

b. Sesqui Compounds.

Sesquimethide of tin . . . . . $Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\end{matrix}\right.$

Sesquiethide of tin . . . . . . $Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.$

Sesquidimethiodide of tin . . . . $Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\I\end{matrix}\right.$

Sesquidiethiodide of tin . . . . . $Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\end{matrix}\right.$

c. Stannic Compounds.

Stannic methide . . . . . . $Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\\C_2H_3\end{matrix}\right.$

Stannic ethide . . . . $Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.$

Stannic ethylodimethide . . . . . $Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_4H_5\\C_4H_5\end{matrix}\right.$

Stannic ethylotrimethide . . . . . $Sn_2\left\{\begin{matrix}C_4H_5\\C_2H_3\\C_2H_3\\C_2H_3\end{matrix}\right.$

Trimethiodide of tin . . . . . $Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\\I\end{matrix}\right.$

Triethiodide of tin . . . . . . $Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\I\end{matrix}\right.$

Dimethiodide of tin or iodide of stanmethyl . $Sn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\I\\I\end{matrix}\right.$

Diethiodide of tin or iodide of stanethyl . . $Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\\I\end{matrix}\right.$

It is scarcely necessary to observe that the iodine in the above compounds admits of replacement by any salt-forming radical, and also by oxygen or sulphur.

Stannous Compounds are oily liquids, possessing a pungent odour, soluble in alcohol and ether, but insoluble in water. They cannot be distilled without decomposition, being resolved into stannic compounds and metallic tin. Stannous compounds are in a state of partial chemical saturation only, they therefore perform the part of radicals, combining directly with chlorine, oxygen, &c and forming well marked bodies of great stability.

The stannous compounds represented by the above formulæ are biatomic, and unite directly with free oxygen, chlorine, &c. to produce bodies of the stannic form. Thus, stannous ethide forms with oxygen stannic diethoxide:

$$\underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Stannous ethide.}} + O_2 = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\O\\O\end{matrix}\right.}_{\text{Stannic diethoxide.}}$$

Stannous compounds have never yet been observed to play a uniatomic part. No sesquicompound has been directly formed from a stannous body, the latter under the influence of iodine, oxygen, &c. seems to pass at once into the stannic form. It must be remarked, however, that no direct experiments have been made with a view of revealing any uniatomic attribute which may attach to stannous compounds.

Sesquicompounds of the form $Sn_2\left\{\begin{matrix}R+\\R+\\R+\end{matrix}\right.$ have hitherto been very little examined, they are oily liquids uniting directly with negative radicals, and forming extensive series of compounds belonging to the stannic class, a considerable number of which have been studied. The following examples will serve to show the mode in which sesquicompounds of this form pass into bodies of the stannic class:

$$\underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Sesquiethide of tin.}} + I = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\I\end{matrix}\right.}_{\text{Stannic triethiodide.}}$$

$$\underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\I\end{matrix}\right.}_{\text{Stannic triethiodide.}} + I_2 = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\\I\end{matrix}\right.}_{\text{Stannic diethiodide.}} + \underbrace{\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}}$$

No reduction of a sesqui to a stannous compound has yet been effected, although it can scarcely be doubted that an aqueous solution of sesquidiethiodide of tin, for instance, if treated with zinc, would yield stannous ethide. On the other hand, an instance of the reduction of a stannic to a sesquicompound has been observed. Thus stannic ethylodimethide in contact with iodine is transformed into sesquidiethiodide of tin.

$$\underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Stannic ethylodimethide.}} + I_2 = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\end{matrix}\right.}_{\text{Sesquidiethiodide of tin.}} + \underbrace{2C_2H_3I}_{\text{Iodide of methyl.}}$$

Sesquicompounds of the form $Sn_2\left\{\begin{matrix}R+\\R+\\R-\end{matrix}\right.$ are very little known; in fact the sesquidiethiodide of tin $\left(Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\end{matrix}\right.\right)$, the production of which from stannic ethylodimethide has just been mentioned, is the only one known with certainty. It is a colourless mobile liquid, possessing a most insupportable odour, like essential oil of mustard, and boiling with partial decomposition at a high temperature. Heated with an excess of iodine, it is transformed into stannic diethiodide:

$$\underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\end{matrix}\right.}_{\text{Sesquidiethiodide of tin.}} + I = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\\I\end{matrix}\right.}_{\text{Stannic diethiodide.}}$$

Stannic compounds of the form $Sn_2\left\{\begin{matrix}R+\\R+\\R+\\R+\end{matrix}\right.$ are colourless mobile liquids, possessing a slight ethereal odour. They are volatile without decomposition, and possess great stability. Being in the condition of chemical saturation they are incapable of direct combination. No body can act upon them without expelling one or more equivalents of positive radical. Thus, when heated with hydrochloric acid, stannic ethide yields stannic triethochloride and hydride of ethyl:

$$\underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Stannic ethide.}} + HCl = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\Cl\end{matrix}\right.}_{\text{Stannic triethochloride.}} + \underbrace{\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}}_{\text{Hydride of ethyl.}}$$

With two equivalents of iodine the reaction is:

$$\underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Stannic ethide.}} + I_2 = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\I\end{matrix}\right.}_{\text{Stannic triethiodide.}} + \underbrace{\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}}_{\text{Iodide of ethyl.}}$$

And with four equivalents of iodine:

$$\underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Stannic ethide.}} + I_4 = \underbrace{Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\\I\end{matrix}\right.}_{\text{Stannic diethiodide.}} + 2\left.\begin{matrix}C_4H_5\\I\end{matrix}\right\}$$

Stannic compounds of the form $Sn_2\left\{\begin{matrix}R+\\R+\\R+\\R-\end{matrix}\right.$ commonly called compounds of sesquistanethyl, have been comparatively well studied. The oxides are, in the anhydrous condition, volatile limpid oily liquids, which readily unite with water, forming crystalline hydrates possessing a powerful alkaline reaction, and neutralising the strongest acids, with which they form an extensive series of salts. These salts are also a soluble in water, readily crystallisable, and possess a pungent odour. The stannic triethiodide and the sulphate of sesquistanethyl may be adduced as examples of the haloid and oxysalts respectively.

Stannic triethiodide	$Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\I\end{matrix}\right.$
Stannic triethylosulphate	$Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\SO_4\end{matrix}\right.$

Stannic compounds of the form $Sn_2\left\{\begin{matrix}R+\\R+\\R-\\R-\end{matrix}\right.$ have also been very completely investigated. The oxides are white amorphous powders, insoluble in water, alcohol, and ether. They dissolve in hydrochloric, hydriodic, and hydrobromic acids, forming colourless and inodorous salts crystallising in fine prisms. Most of the oxysalts can also be obtained in the crystalline form, either from aqueous or alcoholic solutions. The iodide and sulphate of stannic diethide, which may be regarded as representatives of the haloid and oxysalts, have the following formulæ:

Iodide of stannic diethide	$Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\I\\I\end{matrix}\right.$
Sulphate of stannic diethide	$Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\SO_4\\SO_4\end{matrix}\right.$

Stannic compounds of this form are readily reduced to stannous compounds; thus, when a piece of zinc is plunged into a solution of stannic diethochloride, stannous ethide is produced:

$$Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\Cl\\Cl\end{matrix}\right. + Zn_2 = Sn_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right. + 2ZnCl$$

Bismuth Series.—The following bodies belonging to this series have been described:

1. Bismuthous ethide	$Bi\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.$
2. Bismuthous dichlorethide	$Bi\left\{\begin{matrix}C_4H_5\\Cl\\Cl\end{matrix}\right.$
3. Bismuthous diiodoethide . . .	$Bi\left\{\begin{matrix}C_4H_5\\I\\I\end{matrix}\right.$
4. Bismuthous dioxyethide	$Bi\left\{\begin{matrix}C_4H_5\\O\\O\end{matrix}\right.$?
5. Double compound of bismuthous sulphide with bismuthic disulphethide	$Bi\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\S\\S\end{matrix}\right. + 2BiS_3$?

These bodies have as yet been only very imperfectly investigated. Bismuthous ethide is a colourless or slightly yellow mobile liquid, having an unpleasant odour like stibethine. Exposed to the air it gives off dense yellow fumes, inflames spontaneously, and finally explodes. It is very instable, begins to decompose at 50° to 60° C., and explodes violently when heated to 150° C., a temperature still below its boiling point. No direct compound of this body has yet been obtained; it behaves like a chemically saturated substance, and when slowly oxidised in contact with water, yields alcohol and hydrated oxide of bismuth.

$$Bi\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right. + 3\left.\begin{matrix}H\\H\end{matrix}\right\}O_2 + O_6 = BiO_3,\,3HO + 3\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}O_2$$

When an alcoholic solution of bichloride of mercury is added to an alcoholic solution of bismuthous ethide, mercuric etho-chloride crystallises out, whilst bismuthous dichlorethide remains in solution:

$$\underbrace{Bi\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Bismuthous ethide.}} + 2HgCl_2 = \underbrace{Bi\left\{\begin{matrix}C_4H_5\\Cl\\Cl\end{matrix}\right.}_{\text{Bismuthous dichlorethide.}} + \underbrace{2Hg\left\{\begin{matrix}C_4H_5\\Cl\end{matrix}\right.}_{\text{Mercuric ethochloride.}}$$

From the bismuthous dichlorethide, the biniodide and binoxide are prepared by double decomposition; whilst the simultaneous action of sulphuretted hydrogen, water, bismuthous triethide and atmospheric oxygen is said to produce the double compound of bismuthous sulphide and bismuthic disulphethide.

Lead series.—The following bodies are known, the ethyl group alone having been explored.

Diplumbotriethyl	$Pb_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.$?
Oxide of diplumbotriethyl	$Pb_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\O\end{matrix}\right.$
Chloride of diplumbotriethyl	$Pb_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\Cl\end{matrix}\right.$
Sulphate of diplumbotriethyl	$Pb_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\SO_4\end{matrix}\right.$
Plumbic ethide	$Pb_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.$

The existence of the first of these bodies cannot be said to be clearly established, but by the action of an alloy of sodium and lead upon iodide of ethyl, a colourless mobile volatile liquid is obtained, which, when dissolved in alcohol or ether, and exposed to the air, forms the oxide of diplumbotriethyl, a body which, however, is more readily obtained by the decomposition of the chloride with oxide of silver.

$$\underbrace{Pb_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\Cl\end{matrix}\right.}_{\text{Chloride of diplumbotriethyl.}} + AgO = \underbrace{Pb_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\O\end{matrix}\right.}_{\text{Oxide of diplumbotriethyl.}} + AgCl$$

Plumbic ethide is a colourless limpid fluid with a faint odour, soluble in ether, but insoluble in water. It is not acted upon by oxygen at ordinary temperatures, but chlorine, bromine, and iodine act violently upon it. Plumbic ethide belongs to the class of saturated bodies, and is consequently incapable of forming compounds. Treated with hydrochloric acid, hydride of ethyl separates, and chloride of plumbotriethide is formed.

$$\underbrace{Pb_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Plumbic ethide.}} + HCl = \underbrace{Pb_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\\Cl\end{matrix}\right.}_{\text{Chloride of diplumbotriethyl.}} + \underbrace{\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}}_{\text{Hydride of ethyl.}}$$

From the plumbotriethide the sulphate and other salts can be prepared by double decomposition. These salts may also be obtained still more readily from the oxide, which is a crystalline volatile pungent body, possessing a powerful alkaline reaction, and attracting carbonic acid from the air.

Mercury series.—This series is confined to bodies of the mercuric type, no organo-mercurous compound having been yet produced. It comprises the following members:—

Mercuric methiodide	$Hg\left\{\begin{matrix}C_2H_3\\I\end{matrix}\right.$
Hydrate of mercuric methoxide	$Hg\left\{\begin{matrix}C_2H_3\\HO_2\end{matrix}\right.$
Nitrate of mercuric methoxide	$Hg\left\{\begin{matrix}C_2H_3\\NO_6\end{matrix}\right.$
Mercuric methide	$Hg\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.$
Mercuric ethiodide	$Hg\left\{\begin{matrix}C_4H_5\\I\end{matrix}\right.$
Hydrate of mercuric ethoxide	$Hg\left\{\begin{matrix}C_4H_5\\HO_2\end{matrix}\right.$
Nitrate of mercuric ethoxide	$Hg\left\{\begin{matrix}C_4H_5\\NO_6\end{matrix}\right.$
Mercuric ethide, or hydrargethyl	$Hg\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.$
Mercuric ethylomethide	$Hg\left\{\begin{matrix}C_2H_3\\C_4H_5\end{matrix}\right.$?
Mercury allyl	$Hg\left\{\begin{matrix}C_6H_5\\C_6H_5\end{matrix}\right.$

Mercuric methide and mercuric-ethide are colourless ethereal volatile bodies, insoluble in water, but soluble in alcohol and ether, and possessing great stability. They are in a state of maximum saturation and cannot therefore unite with any other body without the expulsion of an equivalent of positive radical: thus with bromine, mercuric ethide gives bromide of ethyl and mercuric ethylobromide:

$$\underbrace{Hg\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.}_{\text{Mercuric ethyl.}} + 2Br = \underbrace{Hg\left\{\begin{matrix}C_4H_5\\Br\end{matrix}\right.}_{\text{Mercuric ethylobromide.}} + \underbrace{\left.\begin{matrix}C_4H_5\\Br\end{matrix}\right\}}_{\text{Bromide of ethyl.}}$$

Mercuric methide possesses the highest specific gravity of any known non-metallic liquid (3·069). Glass consequently floats upon its surface. Brought into contact with mercuric iodide, mercuric methide and mercuric ethide are converted respectively into mercuric methiodide and mercuric ethiodide. Thus mercuric methide gives—

$$\underbrace{Hg\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Mercuric methide.}} + Hg\left\{\begin{matrix}I\\I\end{matrix}\right. = \underbrace{2Hg\left\{\begin{matrix}C_2H_3\\I\end{matrix}\right.}_{\text{Mercuric methiodide.}}$$

The reaction with bichloride of mercury is exactly analogous.

The hydrates of mercuric methoxide and mercuric ethoxide are caustic alkaline bases capable of expelling ammonia from its salts, and behaving in a manner similar to the corresponding uniatomic compounds of tin and lead. The remaining mercury compounds which may be considered as derivatives of these two bodies, are represented in the above list by the iodides and nitrates; they generally crystallise very readily, and, with the exception of the haloid compounds, are soluble in water. When their aqueous solutions are treated with zinc they are decomposed, the zinc becomes amalgamated, and gaseous hydrides of the positive radicals are evolved. It is highly probable that there are two stages in this reaction, organozinc compounds being first formed and then decomposed by contact with water, thus with mercuric methiodide—

$$\underbrace{2Hg\left\{\begin{matrix}C_2H_3\\I\end{matrix}\right.}_{\text{Mercuric methiodide.}} + Zn_4 = \underbrace{Zn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Zincmethyl.}} + 2ZnI + 2Hg$$

and then:

$$\underbrace{Zn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Zincmethyl.}} + \underbrace{\left.\begin{matrix}H\\H\end{matrix}\right\}O_2}_{\text{Water.}} = \underbrace{2\left.\begin{matrix}C_2H_3\\H\end{matrix}\right\}}_{\text{Hydride of methyl.}} + 2ZnO$$

This view of the reaction is confirmed by the fact that when zinc acts upon mercuric methiodide at 150° C., zincmethyl is produced.

When one of the above iodides, or the corresponding chloride or bromide, is treated with an organozinc compound, the negative element becomes replaced by the alcohol radical of the zinc compound; thus when mercuric methiodide is treated with zincmethyl, mercuric methide is produced, and it is believed that by acting upon mercuric ethochloride with zincmethyl, mercuric ethylomethide is produced.

$$\underbrace{2Hg\left\{\begin{matrix}C_4H_5\\Cl\end{matrix}\right.}_{\text{Mercuric ethochloride.}} + \underbrace{Zn_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.}_{\text{Zincmethyl.}} = \underbrace{2Hg\left\{\begin{matrix}C_4H_5\\C_2H_3\end{matrix}\right.}_{\text{Mercuric ethylomethide.}} + 2ZnCl$$

but this body has not yet been obtained in a state of purity. Distillation gradually resolves it into mercuric methide and mercuric ethide:—

Antimony series.—This series of organometallic bodies contains a greater number and variety of compounds than any other with the exception of arsenic. The remarkable polyatomic character of antimony and arsenic not only renders the possible number of their organo-compounds very large, but the variation in the proportions of the positive and negative molecules gives an extremely wide range to their chemical character, extending as it does from highly caustic bases on the one hand to powerful bibasic acids ou the other. The following are the principal compounds belonging to this series:—

Trimethylstibine	$Sb\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\end{matrix}\right.$
Antimonic trimethyloxide	$Sb\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\\O\\O\end{matrix}\right.$
Antimonic trimethylchloride	$Sb\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\\C_2H_3\\Cl\\Cl\end{matrix}\right.$
Iodide of tetramethylstibonium	$Sb\left\{\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\\C_2H_3\\I\end{matrix}\right.$

Antimonic trimethylosulphate	$Sb\left\{\begin{array}{l}C_2H_3\\C_2H_3\\C_2H_3\\SO_4\\SO_4\end{array}\right.$
Sulphate of tetramethylstibonium	$Sb\left\{\begin{array}{l}C_2H_3\\C_2H_3\\C_2H_3\\C_2H_3\\SO_4\end{array}\right.$
Triethylstibine	$Sb\left\{\begin{array}{l}C_4H_5\\C_4H_5\\C_4H_5\end{array}\right.$
Antimonic triethyloxide	$Sb\left\{\begin{array}{l}C_4H_5\\C_4H_5\\C_4H_5\\O\\O\end{array}\right.$
Antimonic triethylchloride	$Sb\left\{\begin{array}{l}C_4H_5\\C_4H_5\\C_4H_5\\Cl\\Cl\end{array}\right.$
Iodide of tetraethylstibonium	$Sb\left\{\begin{array}{l}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\\I\end{array}\right.$
Iodide of methylotriethylstibonium	$Sb\left\{\begin{array}{l}C_4H_5\\C_4H_5\\C_4H_5\\C_2H_3\\I\end{array}\right.$
Antimonic triethylosulphate	$Sb\left\{\begin{array}{l}C_4H_5\\C_4H_5\\C_4H_5\\SO_4\\SO_4\end{array}\right.$
Sulphate of tetraethylostibonium	$Sb\left\{\begin{array}{l}C_4H_5\\C_4H_5\\C_4H_5\\C_4H_5\\SO_4\end{array}\right.$
Antimonic triethylantiomonite	$Sb\left\{\begin{array}{l}C_4H_5\\C_4H_5\\C_4H_5\\SbO_4\\SbO_4\end{array}\right.$
Antimonic triethyloxyiodide	$Sb\left\{\begin{array}{l}C_4H_5\\C_4H_5\\C_4H_5\\O\\I\end{array}\right.$
Triamylstibine	$Sb\left\{\begin{array}{l}C_{10}H_{11}\\C_{10}H_{11}\\C_{10}H_{11}\end{array}\right.$
Antimonic triamylchloride	$Sb\left\{\begin{array}{l}C_{10}H_{11}\\C_{10}H_{11}\\C_{10}H_{11}\\Cl\\Cl\end{array}\right.$
Antimonic triamylnitrate	$Sb\left\{\begin{array}{l}C_{10}H_{11}\\C_{10}H_{11}\\C_{10}H_{11}\\NO_6\\NO_6\end{array}\right.$

It is remarkable that we have as yet no decisive evidence of the existence in this series of a compound corresponding to cacodyl. It is true that such a body has been described under the name of *stibbiamyl*, but subsequent experiments have failed to confirm its existence. Amongst organo-antimony compounds, therefore, the most simple form is $Sb\left\{\begin{array}{l}R+\\R+\\R+\end{array}\right.$ bodies of this form, and of the type $Sb\left\{\begin{array}{l}R+\\R+\\R+\\R+\\R-\end{array}\right.$ are the analogues of ammonia and its derivatives; for a description of them, see ORGANIC BASES.

The only bodies therefore of this series requiring notice here are those of the form $Sb\left\{\begin{array}{l}R+\\R+\\R+\\R-\\R-\end{array}\right.$ and their derivatives. When the two atoms of negative radical are oxygen, these compounds constitute what may be termed biacid antimony bases. They are formed either by the direct union of the stibamines $\left(Sb\left\{\begin{array}{l}R+\\R+\\R+\end{array}\right.\right)$ with oxygen;

$$Sb\left\{\begin{array}{l}R+\\R+\\R+\end{array}\right. + O_2 = Sb\left\{\begin{array}{l}R+\\R+\\R+\\O\\O\end{array}\right.$$

or by the decomposition of the corresponding haloid compounds by means of potash, thus—

$$Sb\left\{\begin{array}{l}R+\\R+\\R+\\Cl\\Cl\end{array}\right. + 2KO = Sb\left\{\begin{array}{l}R+\\R+\\R+\\O\\O\end{array}\right. + 2KCl$$

The stibamines, although in other respects the perfect analogues of the nitramines, here exhibit a much more highly positive character, uniting with oxygen so energetically as to be spontaneously inflammable in the lower portion of the series.

The biacid antimony bases are colourless, transparent, amorphous, and tenacious bodies, the ethylic base is easily soluble in water and alcohol, but somewhat less soluble in ether. They possess a bitter taste, are non-volatile, and do not suffer any change when exposed to the air. Treated with potassium they are reduced to stibamines.

$$Sb\left\{\begin{array}{l}R+\\R+\\R+\\O\\O\end{array}\right. + 2K = Sb\left\{\begin{array}{l}R+\\R+\\R+\end{array}\right. + 2KO$$

Fuming nitric acid decomposes the biacid bases with ignition, but when treated with dilute nitric acid, or other acid, the respective biacid salts are produced. The oxysalts are soluble in water and alcohol, most of them crystallise without much difficulty, as does also the biniodide, but the bibromide and bichloride of the ethylic base are liquids not volatile without decomposition, insoluble in water, but soluble in alcohol and ether.

Arsenic series.—This series is perhaps the most important and interesting amongst organo-metallic bodies; it contains the first discovered organo-metal, Cacodyl, the classical investigation of which by Bunsen, imparts not merely a completeness to our knowledge of this series, but has afforded the clue to the successful interpretation of many phenomena met with in other analogous series. It will be convenient to divide its very numerous members into three groups:—

A. Organo-arsenical compounds of the type	$As\left\{\begin{array}{l}R\\R\end{array}\right.$
B. Organo-arsenical compounds of the type	$As\left\{\begin{array}{l}R\\R\\R\end{array}\right.$
C. Organo-arsenical compounds of the type	$As\left\{\begin{array}{l}R\\R\\R\\R\\R\end{array}\right.$

All arsenical compounds permit of being arranged under these three types. The following are the principal bodies already investigated:—

A. *Organo-arsenical compounds of the type* $As\left\{\begin{array}{l}R\\R\end{array}\right.$

Cacodyl	$As\left\{\begin{array}{l}C_2H_3\\C_2H_3\end{array}\right.$
Ethylic cacodyl	$As\left\{\begin{array}{l}C_4H_5\\C_4H_5\end{array}\right.$

B. *Organo-arsenical compounds of the type* $As\left\{\begin{array}{l}R\\R\\R\end{array}\right.$

Oxide of cacodyl	$As\left\{\begin{array}{l}C_2H_3\\C_2H_3\\O\end{array}\right.$
Chloride of cacodyl	$As\left\{\begin{array}{l}C_2H_3\\C_2H_3\\Cl\end{array}\right.$
Chloride of cacoplatyl	$As\left\{\begin{array}{l}C_2H_3\\C_2Pt''H\\Cl\end{array}\right.$
Arsenious dioxymethide	$As\left\{\begin{array}{l}C_2H_3\\O\\O\end{array}\right.$
Arsenious dichlormethide	$As\left\{\begin{array}{l}C_2H_3\\Cl\\Cl\end{array}\right.$
Trimethylarsine	$As\left\{\begin{array}{l}C_2H_3\\C_2H_3\\C_2H_3\end{array}\right.$

Triethylarsine	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_4H_5}\\ \mathrm{C_4H_5}\\ \mathrm{C_4H_5}\end{matrix}\right.$

C. *Organo-arsenical compounds of the type* $\mathrm{As}\left\{\begin{matrix}\mathrm{R}\\ \mathrm{R}\\ \mathrm{R}\\ \mathrm{R}\\ \mathrm{R}\end{matrix}\right.$

This group may be conveniently sub-divided into four families, namely:

a. Bodies of the form $\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}-\\ \mathrm{R}-\\ \mathrm{R}-\\ \mathrm{R}-\end{matrix}\right.$ and their derivatives.

b. Bodies of the form $\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}-\\ \mathrm{R}-\\ \mathrm{R}-\end{matrix}\right.$ and their derivatives.

c. Bodies of the form $\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}-\\ \mathrm{R}-\end{matrix}\right.$ and their derivatives.

d. Bodies of the form $\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}-\end{matrix}\right.$ and their derivatives.

a. Bodies of the form $\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}-\\ \mathrm{R}-\\ \mathrm{R}-\\ \mathrm{R}-\end{matrix}\right.$

Monomethylarsenic acid	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\end{matrix}\right.$
Monomethylarseniates	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{MO_2}\\ \mathrm{MO_2}\end{matrix}\right.$
Arsenic dioxydichlormethide	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{O}\\ \mathrm{O}\end{matrix}\right.$

b. Bodies of the form $\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}-\\ \mathrm{R}-\\ \mathrm{R}-\end{matrix}\right.$

Cacodylic acid	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\end{matrix}\right.$
Cacodylates	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{MO_2}\end{matrix}\right.$
Terchloride of cacodyl.	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right.$

c. Bodies of the form $\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}-\\ \mathrm{R}-\end{matrix}\right.$

Arsenic triethyloxide	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_4H_5}\\ \mathrm{C_4H_5}\\ \mathrm{C_4H_5}\\ \mathrm{O}\\ \mathrm{O}\end{matrix}\right.$
Arsenic triethyliodide	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_4H_5}\\ \mathrm{C_4H_5}\\ \mathrm{C_4H_5}\\ \mathrm{I}\\ \mathrm{I}\end{matrix}\right.$

d. Bodies of the form $\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}-\end{matrix}\right.$

Oxide of tetramethylarsonium	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{O}\end{matrix}\right.$
Iodide of tetramethylarsonium	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{I}\end{matrix}\right.$
Oxide of dimethyl-diethyl-arsonium . . .	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{C_4H_5}\\ \mathrm{C_4H_5}\\ \mathrm{O}\end{matrix}\right.$
Chloride of tetrethylarsonium	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_4H_5}\\ \mathrm{C_4H_5}\\ \mathrm{C_4H_5}\\ \mathrm{C_4H_5}\\ \mathrm{Cl}\end{matrix}\right.$
Iodide of dimethyl-diamyl-arsonium . . .	$\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{C_{10}H_{11}}\\ \mathrm{C_{10}H_{11}}\\ \mathrm{I}\end{matrix}\right.$

The organo-arsenical compounds belonging to the type $\mathrm{As}\left\{\begin{matrix}\mathrm{R}\\ \mathrm{R}\end{matrix}\right.$ contain only positive radicals. They are volatile poisonous liquids, insoluble in water, but very soluble in alcohol and ether, possessing an insupportable odour. The lower members of the family are spontaneously inflammable, whilst the higher ones also rapidly oxidise in air. They unite with negative elements with great energy, manifesting in their combinations either a uniatomic or a teratomic character, and producing bodies respectively of the forms $\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ -\end{matrix}\right.$ and $\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}-\\ \mathrm{R}-\\ \mathrm{R}-\end{matrix}\right.$.

Thus cacodyl forms with chlorine, chloride of cacodyl and terchloride of cacodyl.

$$\underbrace{\mathrm{As(C_2H_3)_2}}_{\text{Cacodyl.}} + \mathrm{Cl} = \underbrace{\mathrm{As(C_2H_3)_2Cl}}_{\text{Chloride of cacodyl.}}$$

$$\underbrace{\mathrm{As(C_2H_3)_2}}_{\text{Cacodyl.}} + \mathrm{Cl_3} = \underbrace{\mathrm{As(C_2H_3)_2Cl_3}}_{\text{Terchloride of cacodyl.}}$$

Methylic cacodyl boils at 338° F., and ethylic cacodyl between 365° and 374°.

Heated to 750°, cacodyl splits up into metallic arsenic, hydride of methyl, and olefiant gas.

$$\underbrace{\mathrm{2As(C_2H_3)_2}}_{\text{Cacodyl.}} = \mathrm{As_2} + \underbrace{2\left.\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{H}\end{matrix}\right\}}_{\text{Hydride of methyl.}} + \underbrace{\mathrm{C_4H_4}}_{\text{Olefiant gas.}}$$

Bodies of this type can be regenerated from many of their uniatomic compounds by reducing agents; thus chloride of cacodyl and metallic zinc give cacodyl and chloride of zinc:—

$$\underbrace{\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{Cl}\end{matrix}\right.}_{\text{Chloride of cacodyl.}} + \mathrm{Zn} = \underbrace{\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\end{matrix}\right.}_{\text{Cacodyl.}} + \mathrm{ZnCl}$$

Organo-arsenical compounds of the type $\mathrm{As}\left\{\begin{matrix}\mathrm{R}\\ \mathrm{R}\\ \mathrm{R}\end{matrix}\right.$ are of three forms, namely—

$$\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}+\end{matrix}\right. \qquad \mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}-\end{matrix}\right. \qquad \mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}-\\ \mathrm{R}-\end{matrix}\right.$$

Those belonging to the first are termed *arsines*, and are the analogues of ammonia, but like the corresponding antimony compounds, in addition to their alkaloid functions they have the power of combining with two negative atoms, forming bodies of the sub-type

$$\mathrm{As}\left\{\begin{matrix}\mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}+\\ \mathrm{R}-\\ \mathrm{R}-\end{matrix}\right.$$

Thus triethylarsine combines with oxygen to form arsenic dioxyethide.

The lower members of this type possess this power to such an extent as to render them spontaneously inflammable in air.

Compounds belonging to the second of the above sub-types are produced by the direct combinations of the cacodyles with negative elements, the oxides are bases of comparatively feeble power, slowly combining with two additional equivalents of oxygen to form acids. Thus oxide of cacodyl by exposure to air slowly passes into cacodylic acid :—

$$\underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\C_2H_3\\O\end{matrix}\right.}_{\text{Oxide of cacodyl.}} + O_2 = \underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\C_2H_3\\O\\O\\O\end{matrix}\right.}_{\text{Cacodylic acid.}}$$

The chlorine, bromine, and iodine compounds of this type are volatile neutral bodies, which may be regarded as the haloid salts of cacodyl. Heated in contact with bichloride of platinum, the chloride of cacodyl presents an interesting reaction; two equivalents of hydrogen in the cacodyl become replaced by a biatomic molecule of platinum, producing chloride of cacoplatyl :—

$$\underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\C_2H_3\\Cl\end{matrix}\right.}_{\text{Chloride of cacodyl.}} + PtCl_2 = \underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\C_2Pt''H\\l\end{matrix}\right.}_{\text{Chloride of cacoplatyl.}} + 2HCl$$

Cacoplatyl forms a series of compounds analogous to those of cacodyl.

The only compounds of the third form yet known belong to the methylic group. Arsenious dioxymethide is a crystalline body of a neutral character, soluble in water, alcohol, and ether; unchanged by exposure to air, but transformed by distillation with hydrate of potash into arsenious acid and oxide of cacodyl.

$$2\mathrm{As}\left\{\begin{matrix}C_2H_3\\O\\O\end{matrix}\right. = AsO_3 + \mathrm{As}\left\{\begin{matrix}C_2H_3\\C_2H_3\\O\end{matrix}\right.$$

Hydrochloric acid converts it into arsenious dichlormethide

$$\underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\O\\O\end{matrix}\right.}_{\text{Arsenious dioxymethide.}} + 2HCl = \underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\Cl\\Cl\end{matrix}\right.}_{\text{Arsenious dichlormethide.}} + \left.\begin{matrix}H\\H\end{matrix}\right\}O_2$$

Hydrobromic and hydriodic acids produce a perfectly analogous change, whilst sulphuretted hydrogen transforms it into arsenious disulphomethide. The chlorine compound can also be formed by heating arsenic trichlormethide to 122° F.

$$\underbrace{As(C_2H_3)_2Cl_3}_{\text{Arsenic trichlormethide.}} = \underbrace{As(C_2H_3)Cl_2}_{\text{Arsenious dichlormethide.}} + \underbrace{C_2H_3Cl}_{\text{Chloride of methyl.}}$$

The chlorine, bromine, and iodine compounds are neutral bodies of considerable stability; the two former are liquid, the latter solid and crystalline. By the action of chlorine or oxidising agents, they are transformed into bodies of the form $\mathrm{As}\left\{\begin{matrix}R+\\R-\\R-\\R-\\R-\end{matrix}\right.$

Sub-type $\mathrm{As}\left\{\begin{matrix}R+\\R-\\R-\\R-\\R-\end{matrix}\right.$ has only yet been explored in the methylic group. The oxygen compound constitutes anhydrous monomethylarsenic acid, a direct derivative from arsenious dioxymethide.

$$\underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\O\\O\end{matrix}\right.}_{\text{Arsenious dioxymethide.}} + 2AgO = \underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\O\\O\\O\\O\end{matrix}\right.}_{\text{Monomethylarsenic acid.}} + 2Ag$$

This acid is bibasic, forming stable and well-defined crystallisable salts, the formulæ of which are represented by the general expression

$$\mathrm{As}\left\{\begin{matrix}C_2H_3\\O\\O\\MO_2\\MO_2\end{matrix}\right.$$

The chlorine compound is exceedingly unstable; it may however be formed at 14° F., but is transformed at 32° into arsenious chloride and chloride of methyl.

$$\underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\Cl\\Cl\\Cl\\Cl\end{matrix}\right.}_{\text{Arsenic tetrachlormethide.}} = AsCl_3 + \underbrace{\left.\begin{matrix}C_2H_3\\Cl\end{matrix}\right\}}_{\text{Chloride of methyl.}}$$

Arsenic dioxydichlormethide is a somewhat more stable body formed by the direct union of chlorine with arsenious dioxymethide :

$$\underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\O\\O\end{matrix}\right.}_{\text{Arsenious dioxymethide.}} + Cl_2 = \underbrace{\mathrm{As}\left\{\begin{matrix}C_2H_3\\O\\O\\Cl\\Cl\end{matrix}\right.}_{\text{Arsenic dioxydichlormethide.}}$$

Nevertheless even this compound readily decomposes with the evolution of chloride of methyl.

In sub-type $\mathrm{As}\left\{\begin{matrix}R+\\R+\\R-\\R-\\R-\end{matrix}\right.$ the oxygen compounds are feeble monobasic acids, of which cacodylic acid may be regarded as the representative. They are derived from the bodies $\mathrm{As}\left\{\begin{matrix}R+\\R+\\O\end{matrix}\right.$ by direct oxidation, as already described. Cacodylic acid is remarkable for its stability, neither fuming nitric acid nor a mixture of sulphuric and chromic acids attack it even at the boiling point, and it may be heated to 390° F. without alteration. Although it is soluble in water, and contains upwards of 54 per cent. of arsenic, yet it is not in the least poisonous. Several deoxidising agents reduce cacodylic acid to the arsenious, or even to the diatomic, form. Thus phosphorous acid transforms it into cacodyl:

$$\underbrace{2(As(C_2H_3)_2O_3)}_{\text{Cacodylic acid.}} + 3(PO_3) = \underbrace{2As(C_2H_3)_2}_{\text{Cacodyl.}} + 3PO_5$$

Zinc also produces the same result.

The cacodylates have the formula

$$As(C_2H_3)_2O_3, MO.$$

Sulphocacodylic acid has not yet been isolated, but its salts present the same relation to those of cacodylic acid as salts of sulphur acids generally bear to those of oxyacids. Their formula is

$$As(C_2H_3)_2S_3, MS.$$

Sub-type $\mathrm{As}\left\{\begin{matrix}R+\\R+\\R+\\R-\\R-\end{matrix}\right.$ has hitherto been very little explored: so far as it is known, however, its members bear so close a resemblance to their analogues in the antimony series as to require no further notice.

Tellurium Series. The close relations of tellurium to sulphur and selenium place the organometallic bodies of this series in the same position with regard to the sulphides and selenides of the alcohol radicals, as the antimony and arsenic series stand in relation to the corresponding compounds of phosphorus and nitrogen.

The following are the chief known compounds:

Tellurium-methyl	$Te_2\left\{\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right.$
Tellurous dimethoxide	$Te_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\O\\O\end{matrix}\right.$
Tellurous methoxychloride	$Te_2\left\{\begin{matrix}C_2H_3\\C_2H_3\\O\\Cl\end{matrix}\right.$
Telluriumethyl	$Te_2\left\{\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right.$
Tellurous diethoxide	$Te_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\O\\O\end{matrix}\right.$
Tellurous diethochloride	$Te_2\left\{\begin{matrix}C_4H_5\\C_4H_5\\Cl\\Cl\end{matrix}\right.$
Telluriumamyl	$Te_2\left\{\begin{matrix}C_{10}H_{11}\\C_{10}H_{11}\end{matrix}\right.$?

The compounds of the alcohol radicals with tellurium are volatile liquids of most unbearable odour. They readily oxidise in contact with air, forming the respective oxides. Telluriumamyl has not yet been obtained in a state of purity.

The oxides of these bodies are powerful bases, expelling ammonia from its salts and attracting carbonic acid from the air. They form salts of considerable stability, which, together with the oxides themselves, yield the original organo-tellurium compounds when treated with sulphurous acid; thus,

$$\underbrace{\mathrm{Te_2}\left\{\begin{matrix}\mathrm{C_4H_5}\\ \mathrm{C_4H_5}\\ \mathrm{O}\\ \mathrm{O}\end{matrix}\right.}_{\text{Tellurous ethoxide.}} + \mathrm{S_2O_4} = \underbrace{\mathrm{Te_2}\left\{\begin{matrix}\mathrm{C_4H_5}\\ \mathrm{C_4H_5}\end{matrix}\right.}_{\text{Telluriumethyl.}} + \mathrm{S_2O_6}$$

CONSTITUTION OF ORGANOMETALLIC BODIES.

The organometallic bodies are supposed to be constructed upon the types of the inorganic chlorides, sulphides, oxides, &c., of the respective metals which they contain, the chlorine, oxygen, sulphur, &c., being replaced in equivalent proportion, and step by step by the alcohol radicals. A reference to the formulæ of organo-potassium, sodium, magnesium, zinc, and cadmium compounds given above, shows that they are all formed upon the models of the protochlorides of these metals:

$$\mathrm{M_2}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right.$$

The organo-aluminium compounds are formed upon the model of the sesquichloride of that metal:

$$\mathrm{Al_2}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right.$$

Organo-tin compounds are in like manner represented by the three chlorides of tin:

$$\mathrm{Sn_2}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right. \qquad \mathrm{Sn_2}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right. \qquad \mathrm{Sn_2}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right.$$

The bismuth series are modelled upon the terchloride of bismuth and bismuthic acid:

$$\mathrm{Bi}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right. \qquad \mathrm{Bi}\left\{\begin{matrix}\mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\end{matrix}\right.$$

The lead compounds are constructed upon two of the oxides of this metal:

$$\mathrm{Pb_2}\left\{\begin{matrix}\mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\end{matrix}\right. \qquad \mathrm{Pb_2}\left\{\begin{matrix}\mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\end{matrix}\right.$$

The mercury series have for their mould the bichloride of mercury:

$$\mathrm{Hg}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right.$$

The antimony series are formed upon the following inorganic compounds of that metal.

$$\mathrm{Sb}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right. \qquad \mathrm{Sb}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right.$$

In like manner organo-arsenical compounds are constructed after the following types:

$$\mathrm{As}\left\{\begin{matrix}\mathrm{S}\\ \mathrm{S}\end{matrix}\right. \qquad \mathrm{As}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right. \qquad \mathrm{As}\left\{\begin{matrix}\mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\end{matrix}\right.$$

Finally, organic compounds containing tellurium are derived from

$$\mathrm{Te_2}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right. \qquad \mathrm{Te_2}\left\{\begin{matrix}\mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\end{matrix}\right.$$

Occasionally an abnormal compound has made its appearance, such as ethostibylic acid ($\mathrm{Sb(C_4H_5)O_8}$), or iodide of triethylstibine ($\mathrm{Sb(C_4H_5)_3I}$), but further research has invariably demonstrated the incorrectness of such formulæ and the conformity of the bodies with the normal inorganic types. Indeed this law may now be regarded as so firmly established, as to be applicable to the control of the formulæ of new organometallic bodies. From this point of view it is interesting to watch the effect of the substitution of chlorous or negative by basylous or positive radicals in metallic compounds. Such a substitution affords striking evidence of the dependence of the chemical character of a compound upon that of its individual constituents; a phenomenon which is strikingly seen in the case of highly polyatomic metals, such as arsenic and antimony. Thus tribasic arsenic acid, by the substitution of an equivalent of methyl for oxygen, yields the bibasic monomethyl-arsenic acid, a well defined acid of considerable energy, though inferior in chlorous power to arsenic acid. The like substitution of a second equivalent of methyl for oxygen reduces the chlorous character of the body to the comparatively feeble condition in which we find it in cacodylic acid, which is incapable of forming an ammonia salt. A similar substitution for the third time overpowers the chlorous character of the compound altogether, and we now have a feeble biacid base—the arsenic dioxymethide; which again, by the exchange of a fourth atom of oxygen for methyl, is transformed into the oxide of tetramethylarsonium, a base of such energy as to be comparable with the caustic alkalies themselves.

The history of the organometallic bodies teaches forcibly a doctrine which affects all chemical compounds, and which may be called the doctrine of *atomic saturation;* each element is capable of combining with a certain limited number of atoms, and this number can never be exceeded, although the energy of its affinities may have been increased by combination up to this point. Thus zinc attains its atomic saturation by uniting with only one atom of another body, in other words, it is uniatomic; consequently, the zinc compounds of the alcohol radicals, notwithstanding their intense affinities, are incapable of combination. The action of chlorous elements upon them is one of substitution, not of combination. Polyatomic metals exhibit the same phenomenon: a double atom of tin cannot combine with more than 4 atoms; a single atom of arsenic or antimony with more than 5 atoms of other bodies. But in the combinations of polyatomic metals, we frequently notice from the lowest to the saturated compound one or more intermediate points of exalted stability; thus, antimony has a teratomic stage of comparative stability; nitrogen, phosphorus, and arsenic, whilst exhibiting a similar teratomic stage, have also a biatomic one, though of greatly inferior stability; whilst the existence of protoxide of nitrogen, and especially the recent researches of Mr. Griess render it more than probable that nitrogen has a third and uniatomic stage. In bodies possessing at least one stage of stability below saturation, and in which all the atoms united with the polyatomic element are of the same kind, the stage of maximum stability is very rarely that of saturation. Thus in nitrogen, arsenic, and bismuth compounds of the kind just mentioned, the stage of maximum stability is decidedly the teratomic one; in antimonial compounds of a similar nature, the teratomic is also, though less decidedly, the stage of maximum stability; whilst in phosphorous compounds, the points of maximum stability and saturation generally coincide. When, however, the atoms united with the polyatomic element are not of the same kind, then the stage of maximum stability usually coincides with that of saturation. Thus the binoxide or bichloride of triethylarsine, or triethylstibine, are more stable than triethylarsine or triethylstibine themselves; but this pentatomic stability reaches its climax in arsonium, stibonium, and phosphonium compounds, as it does also in the corresponding compounds of nitrogen, although the latter element exhibits a much stronger tendency towards universal teratomic stability than its chemical associates.

In polyatomic organometallic bodies it is remarkable that, with few exceptions, the positive hydrocarbons hold their position much more tenaciously than the associated negative constituents; and we thus frequently find the former accompanying the metal through a vast number of compounds; hence the group formed by the metal and positive hydrocarbons has come to be regarded as a compound radical: thus cacodyl is conceived to be the radical of the whole series of cacodyl compounds: but however great may be the convenience of this mode of viewing organometallic compounds, and the same mode has notoriously been extended to nearly all organic bodies, it must not be forgotten that it is a purely artificial distinction which has no real existence, either in the case of organometallic bodies, or in that of organic bodies in general. A close examination of the habits of the so-called organometallic radicals clearly shows that their atomic power depends upon their position with regard to the stages of stability and maximum saturation; thus they are uniatomic when the number of positive groups is one less than that required to reach either the maximum saturation of the metal, or a lower stage of stability. Cacodyl and tetramethylarsonium, for instance, are uniatomic radicals, because they are respectively one atom short of the stage of stability and of maximum saturation:—

$$\begin{array}{cc|cc}
\text{Uniatomic stage.} & \text{Stage of stability.} & \text{Uniatomic stage.} & \text{Stage of maximum saturation.} \\
\underbrace{\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\end{matrix}\right.}_{\text{Cacodyl.}} & \underbrace{\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{Cl}\end{matrix}\right.}_{\text{Chloride of cacodyl.}} & \underbrace{\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{C_2H_3}\end{matrix}\right.}_{\text{Tetramethyl-arsonium.}} & \underbrace{\mathrm{As}\left\{\begin{matrix}\mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{C_2H_3}\\ \mathrm{Cl}\end{matrix}\right.}_{\text{Chloride of tetramethylarsonium.}}
\end{array}$$

It is obvious, that under favourable circumstances, a compound radical, the number of whose positive atoms is below that of a stage of stability, can have a double atomic character. Thus cacodyl is sometimes uniatomic, as in oxide of cacodyl, and sometimes teratomic, as in cacodylic acid ($As(C_2H_3)O_3$). Again, arseniomonomethyl (AsC_2H_3) is biatomic in arsenious dioxymethide and quadratomic in monomethylarsenic acid.

ORGANON. [In the article LOGIC we have explained our reasons for allowing this article, from the pen of the editor of the 'Penny Cyclopædia,' to remain without any attempt to bring it into connection with the new matter of the present work. To it is added the article from the first Supplement to the 'Penny Cyclopædia.']

It is not possible to give a definition of any science which shall convey its full import, and particularly to a person who does not already know what it is. This difficulty will be experienced by any one who attempts to give a definition of Logic. Without then attempting a definition, or admitting the completeness or correctness of any definition hitherto given, it may be sufficient, for the purpose of showing what that matter is about which we are discoursing, to say that logic is conversant about the formal laws of thought, and that it is not conversant about the matter which is subjected to such laws.

This thing, whatever it may be, about which logic is conversant, is presented to us, and is considered by us generally under the form of language. Whatever are the operations of the mind which are involved or contained in the exercise of thought, those operations may be generally expressed by language. It is assumed here, that by whatever names we designate the relation of the various consecutive and connected trains of ideas which pass through the mind, this relation is in all minds essentially the same. When two persons then possess a common language, one of them can express in this language, with a certain degree of accuracy, the various consecutive and connected trains of ideas which have passed through his mind, with respect to any matter or matters. Another person, who, to use the common expression, understands this language, can, through this medium, communicate with the other person's mind; and if the expression of such ideas has been accurately made according to the form of the language, and if they are properly interpreted, the person who hears or reads what the other has written or said, may in his own mind perceive the same various consecutive and connected trains of ideas which the writer or speaker has experienced. If language can effect this, it follows that the mental operations or processes in the two individuals are connected and assimilated by virtue of their both being conformable to the same general laws. It is, however, the laws of thought about which logic is conversant, and with language no further than as being the form of expression in which the thoughts of others are made known to us, and by which we are enabled to compare those thoughts with our own.

Under the article LANGUAGE it has been stated in a general way what language is; but mainly as to the materials of which it is composed. It remains now to consider its form.

What is called a sentence comprehends in its simplest form a subject and a predicate, with something by which a relation between the subject and the predicate is expressed. "Men die" is a sentence, in which "men" is the subject, of which "dying" or "death" is predicated, that is, in this sentence a judgment is expressed. The sentence indicates that two notions are present to the mind, "men" and "death." What the relation is which the mind really contemplates between these two things, and how it is possible for the mind to contemplate this or any other relation between two things, belongs not to the present inquiry, nor to the province of logic. It will be sufficient to observe, that this judgment or relation does not express or mean, as some writers say, any *agreement* or *disagreement* between the two notions, or that one of them belongs or does not belong to the other; nor is it the *comparison* in the mind of these two notions, at least, logically considered, it is not the comparison in the mind of the two notions as to the matter of them.

The sentence "men die" may also be expressed thus,—"men are mortal;" where mortal is the predicate. The grammatical relation between "men" and "mortal," which is the symbolic representation of that conceived by the mind, is expressed in our language by the substantive verb "are," which is accordingly, in such sentences as this, called the copula. In some languages, as the Latin and Greek, which are rich in terminations, the relation between "men" and "mortal" is also expressed by a termination attached to the word "mortal," in addition to the copula, as "homines sunt mortales;" and sometimes the copula *est* is omitted. When there is not a copula, either in the form of the verb "to be" or in some other verb of equivalent meaning, the copula is either expressed solely by the order of the words, which is the case with those languages which, like the English, have few terminations, or the copula is expressed by a verbal termination which has a certain relation of fitness to the nominal termination, as in Latin and Greek, and in some cases by the order of the words also, as "homines moriuntur." The copula in itself has no meaning; its office is to indicate that the subject and the predicate of the sentence are contemplated at once, and each in some relation to the other, in that operation of the mind of which the words "men are mortal" is the visible or sensuous sign. But the subject itself may be qualified by an attribute, or the generality of the subject (which according to the common interpretation of language is understood when it is not limited) may be restricted or confined by the use of appropriate words, as, "dying men are prophetic," or "some dying men are prophetic." Again, the predicate may in like manner be qualified or limited; as "he writes," "he writes a letter," "he writes letters sometimes." Thus every sentence, however complicated it may appear, is reducible to the form of subject, predicate, and copula. "A tall man on horseback in complete armour was seen crossing a deep and rapid river on a winter's day," and other sentences of the kind with which ordinary books of narrative abound, may all be reduced to a simple form. It is true that the number of different things or notions which such a sentence brings before the mind often create a degree of confusion, and render the apprehension of the affirmation or negation, which every simple sentence contains, a matter of some difficulty; and this is particularly the case when a sentence so constructed brings before the mind not material objects with which we are familiar, but notions which express things which are not subject to the cognisance of the senses. And hence it happens that argumentative discourse is not always the most difficult to apprehend. Indeed the difficulty of apprehension is sometimes greatest when the discourse consists of a long series of propositions in which under one set of circumstances one thing is affirmed or denied, or commanded or forbidden; and under another set of circumstances other things are affirmed or denied, or commanded or forbidden; or when things are stated, affirmatively or negatively, with a great many exceptions and limitations. A perusal of a modern act of parliament will show that this is so.

Sometimes there may appear to be, and in fact may be, a difficulty even in a very similar sentence, as to the resolution of it into subject, predicate, and copula. The discussion of this matter belongs to the doctrine of propositions; but so much may be here said, that so far as all propositions are contemplated in their formal and not their material character, they agree in this, that the subject is viewed as something either co-extensive with or included in the predicate. Both the form of language and the form of thought of which language is merely the exponent, forbid us to contemplate a subject in a greater extent than its predicate. The sentence "I hope to succeed" is thus reduced (Whately's 'Logic,' p. 59):—

$$\overbrace{\text{To succeed}}^{\text{sub.}} \qquad \text{is} \qquad \overbrace{\text{what I hope}}^{\text{pred.}};$$

which is the same thing as "success is my hope;" and the remark is made "that an infinitive (which the author has already defined to be a noun substantive) is never the predicate, except when another infinitive is the subject." But we may just as well express the proposition thus:—

$$\overbrace{\text{What I hope}}^{\text{sub.}} \qquad \text{is} \qquad \overbrace{\text{to succeed}}^{\text{pred.}};$$

that is "my hope is success." Now as both "hope" and "success" are general terms, that is, are words capable of being applied severally to an infinity of particular things; and as neither hope nor success are conceived by the mind in any relation of subordination to one another, as that either of containing or contained, or of species and genus [GENUS], it is indifferent whether we use the phrase *my hope* (sub.) is *success* (pred.), or success (sub.) is my hope (pred.). But this sentence, we conceive, would by most people be reduced thus:—

$$\overset{\text{sub.}}{\text{I}} \qquad \overbrace{\text{hope to succeed}}^{\text{pred.}};$$

where "hope of success" is that which the subject, ego, predicates of itself, that is, these words indicate a mental operation in which the subject (it matters not whether contemplating itself or contemplated by another) is viewed (logically) simply as *within* certain limits of predication.

Every simple sentence which is intelligible is reducible to the form A is or is not B; but it should be observed that the former sentence has two meanings, as already observed. It may mean either that A is contained in B, or that A is coextensive with B, where A is the subject, and B the predicate, and *is* the copula. It is important to bear in mind this double meaning of the sentence "A is B." If it should be said that "A is B" may also mean "A contains B," we can then say that B is contained in A; and so we are where we were before. In ordinary language the ambiguity of the form A is B is sometimes removed by words of limitation, as "all," "every," "some;" but frequently there are no such words used, and the consequence is ambiguity.

The sentence "A is not B" may mean either that A is not co-extensive with B, or that no part of A is contained in B, or that some part of A is not contained in B; but this ambiguity also is generally avoided in common speech by the use of words of limitation, or by attaching the negative to the subject. It is obvious that negative propositions are subject to more ambiguity than affirmative propositions. Negative propositions have given logicians much trouble, and it is clear that we only obtain a clear notion of their import by a tacit reference to affirmative propositions. In itself a negative proposition has no meaning; by the very supposition of its being negative, it excludes the notion of all significancy; and yet by means of such propositions we attain to knowledge. The Stoics (who seem to have had a logic of their own) called such a sentence as "Pleasure is not good" an affirmative sentence also: their reasons for this are stated, though somewhat obscurely, by Apuleius. ('Philosophy of Plato,' lib. iii.)

Simple sentences are generally combined in written or spoken discourse in such a manner that the whole meaning of the speaker cannot be reached, except by considering two or more sentences together. Sentences may be so combined, either in the way of co-ordination or sub-ordination, but this distinction, which is made by Dr. Becker in his excellent German grammar, though it is applicable to some extent to all languages, is perhaps more particularly applicable to the German language than to our own. Two sentences are combined by way of co-ordination when they are connected by such a conjunction as *and*, as "he eats and drinks," where we have two distinct sentences, each of which contains a separate and independent affirmation; but we cannot reach the whole of what is said of the subject "he," without contemplating the two sentences together. The conjunction "but" is also often used to unite co-ordinate sentences, as "he speaks German, but not fluently," where the sentence beginning with "but" limits the generality of the former assertion; and the whole sentence does not differ in meaning from "he speaks German, and he speaks German not fluently." Subordinate sentences are connected with the principal sentence in a great variety of ways, among which the union by means of the pronouns and words of pronominal origin is perhaps the most frequent: as, "I do not know when he will come;" "he lives luxuriously, while others are starving."

In both cases, both the combination of co-ordinate sentences and the combination of subordinate with a principal sentence, certain words are used, which are generally distinguished from other words which connect sentences, by the name of *causal;* such are in English, "for," "therefore," "then," and "since" (not as words indicating time), "because," and some others. All languages have words which correspond in meaning to these words. Now it is the combination of sentences produced by such words as these which generally makes up a large part of discourse, written or spoken. When the discourse is bare narration of facts, it is often little more than a succession of affirmative or negative propositions, but so connected and expressed as to render the discourse more pleasing than if the propositions were enunciated separately and in their simple form; but still not logically connected. Besides the ornament and variety which we are enabled to give by written discourse to mere narrative, there is generally a kind of coherence or sequence in the bare facts of narration, which, when some facts are known, can be anticipated by the hearer, or reader, and this again helps to render the language of bare narration less tedious.

But when discourse is not limited to bare narration of facts, it assumes a form which still more interests the hearer or reader, and keeps his intellectual powers in constant exercise. Here the discourse does not barely communicate something from the writer to the reader: it does more; it is constantly addressing itself to those faculties of the reason which the reader and the writer have in common, and it is constantly proceeding on the assumption that a great number of universal propositions are admitted to be true by the reader and the writer. Thus, if we say of a certain man—"he is not liked, because he is presumptuous," two things are affirmed; first, that a "certain man is not liked;" second, "that he is presumptuous." But by the use of the word "because," the writer means to affirm something more than the truth of the two propositions; for we may suppose it possible to affirm many propositions of a man without considering the propositions related to one another in any other way than as all relating to one man as the subject. The words "because he is presumptuous" are designed by the writer to express some connection with or relation to "not being liked," which connection or relation must exist in the mind of all other persons as well as in his own, or it cannot be understood. Now, what is that connection which he and all mankind, and a large part of mankind unconsciously, contemplate when this compound sentence is enunciated? The subject of the whole sentence is some given person or individual who is said "not to be liked," a proposition universally intelligible. He is said "to be presumptuous," which is also universally intelligible. Now, the word "because" has this office:—it introduces something to the reader's notice to which the universal judgment of mankind attaches the notion of dislike; something which is followed by dislike; something without which there may be dislike, but with which there must be dislike; that is, *must be* in this sense: the reader does not know the individual spoken of, and therefore does not know that he is disliked till he is told so; but he knows something of that individual, namely, his presumption, and he also knows that he dislikes a presumptuous individual. He therefore understands the writer, and he admits that statement which is introduced by the word "because" as a *reason* (to use the common expression) why the man is disliked. He has in fact assented to the universal proposition that "a presumptuous man is disliked;" he has already mentally formed for himself a general rule that all presumptuous people are disliked, and it is by virtue of himself and the writer acknowledging this universal affirmation as true, that he collects the writer's meaning. But there is no logical inference here; there is no syllogism.

The speaker or writer might, however, say, all that he knew of a certain man was "that he was presumptuous;" and he might add to the sentence, and "therefore I conclude that he is disliked." If the reader or hearer assented to the conclusion introduced by the word "therefore," he would assent to the following mode of stating what he had heard:—

1. All presumptuous persons are disliked.
2. This man is a presumptuous person;
3. Therefore he is disliked;

which is called a syllogism, and is one of the most common forms of a syllogism, in which the first part, or major premiss, is not expressed. The greatest part of written and spoken discourse is either in this form or in that of a consecutive series of syllogisms, called, by logicians, sorites.

The first two propositions are generally called the *premises*, and the third is called the conclusion; and in such a syllogism everything which is called a conclusion is deduced, or considered as deduced, from two other propositions, one of which, as already observed, is commonly suppressed, but is referred to by such a word as "because," "therefore," &c. It is, however, very clear that nothing is *proved* even by a syllogism. In the common form of language something is affirmed particularly as a fact, and something is said in the way of a conclusion. The mind perceives no reason why this conclusion is made in the particular instance, more than it should be in any other given instance of the same kind. But while something is in form concluded particularly, something is by implication affirmed universally. A person not accustomed to analyse his own thoughts may not always be able to discover what is that universal affirmation which contains the particular conclusion; but if the argument, as it is generally termed, be expressed in the complete form of a syllogism, he at once perceives what universal proposition must be admitted or proved, in order that the particular one shall be true; if he has already given his assent to the proposition as stated, without a clear conception of the extent of the admission which he will be considered to have made, he is enabled by means of the syllogistic form to examine more clearly that mental operation which to him was before confused. The conclusion of the syllogism *proves* nothing; as an inference or illation it necessarily follows from the premises, that is, the mind cannot conceive it otherwise; and in this operation it is subjected to laws of thought which are irresistible. When the truth of the premises is ascertained or admitted (which, for the purpose of argumentation, is the same thing) the conclusion, which before was logically correct, now becomes also true. All discourse of the kind called argumentative, indeed all discourse so far as it contains inferences, may be reduced to the form of a series of syllogisms, from which it will appear what universal affirmations or negations are implicitly contained in the discourse. It will also show what universal affirmations or negations are used as a means of attaining to other affirmations or negations which are not true unless the first are true, and which when attained become the premises of other conclusions. Discourse of the argumentative kind has for its object to establish particular things, or things which are comprehended within other things. Particular things, so far as they are the object of sensuous perceptions, are directly established by evidence, as for instance, the qualities of any material object; but there are many things which are not susceptible of this kind of evidence, and of which there is no evidence but the universal consent of mankind. In an argumentative discourse therefore the writer who has particular things to prove, alleges, expressly or by implication, universal truths, and he affirms, either expressly or by the implication of language, that the particular things are contained within the universal. If the reader assent to the universal truths, and also admit that the particular things are contained therein, the writer accomplishes his purpose, and his demonstration is complete. He is said to have deduced something, or to have made a deduction. If all written or spoken discourse were in the form of perfect syllogisms, there could be little confusion or dispute about what is called the premises and the conclusion, for the whole matter would be so placed before the reader, that he would always perceive the general proposition within which it is affirmed that the particular is included. It is then the general condition of every syllogism imperfectly expressed, that when we are speaking of what we call one thing, we are in effect speaking of many things: for that which is asserted of one can equally be asserted of all things of the kind, and it is not possible to conceive it true of one without conceiving it true of all.

Some writers have observed that the causal conjunctions are employed to denote respectively cause and effect, as well as premiss and conclusion; as in the following examples:—"This ground is rich *because* the trees on it are flourishing;" or, "the trees are flourishing, and *therefore* the soil *must* be rich;" where the conjunctions *because* and *therefore* are considered to be used to denote the connection of premiss and conclusion. But in the following sentences, "the trees flourish *because* the ground is rich;" or "the ground is rich, and *therefore* the trees flourish;" the same conjunctions, it is said, are used to denote the connection of cause and effect; and it is added that in the latter case "the luxuriance of the trees, being evident to the eye, would hardly need to be *proved*, but might need to be accounted for;" and as to the former case, it is remarked, "that the luxuriance of the trees is not the cause of the soil's fertility, but only the cause of *my knowing it*."

Now in the expression, "the trees are flourishing, and *therefore* the soil *must* be rich" (if for *must be* we write *is*, which ought to be done), it may be meant to affirm, either that the trees are flourishing, and that the quality of the soil is unknown; or it may be meant that the trees are flourishing, and that the soil also is rich. In the former case the richness of the soil is concluded, according to the common expression, from the suppressed premiss of the invariable coincidence of flourishing trees and rich soil, and as the world knows or says (which for the present purpose is the same thing) that a rich soil is necessary in order that trees may flourish, the richness of the soil is in fact, according to the common notion of cause and effect, here also considered to be the cause of the luxuriance of the trees, if we look to the matter of the syllogism. In the latter case, if both things are affirmed, both that the trees flourish and that the soil is rich, the same thing is affirmed as in the sentence, "the ground is rich and *therefore* the trees flourish;" and in both these cases, when the two propositions are considered as affirmations, not connected in the way of conclusion, nothing more is effected by the word *therefore* than to suggest the notion of the invariable coincidence of flourishing trees and rich soil.

The Conclusion of the "ground being rich *because* the trees on it are flourishing" (the richness of the ground in question not being known otherwise than by the trees) cannot be made except from the premiss, "wherever trees flourish, there the ground is rich." Now though it may be true that "wherever trees flourish, there the ground is rich," it may not be true that "wherever the ground is rich, there trees flourish," for the ground may be rich, and covered with water in which trees will not flourish. But if we affirm that "the trees flourish *because* the ground is rich," we affirm both "that the trees flourish" and "that the ground is rich," which again is nothing more than affirming by implication that "wherever trees flourish, there the ground is rich," leaving it, as before, possible that there may be rich ground where trees do not (for some reason or other) flourish.

Now it is said that in the former case, where a Conclusion is made, the luxuriance of the trees is considered to be the cause of *my knowing* the fertility of the soil; that is, in the conclusion, "the ground is rich because the trees on it are flourishing;" "the ground is rich" is my (concluded) knowledge, and *because* is there used to express cause and effect, as between "flourishing trees" and "my knowledge." In the latter case, where both propositions are affirmative, but neither of them in the way of conclusion, it is said that the luxuriance of the trees does not require *proof*, but requires to be accounted for; that is, richness of soil and luxuriance are here considered in the relation of cause and effect. According to this, *a* relation of cause and effect, though not of the same cause and effect, is indicated in both cases by the word *because:* and in the former case the richness of the soil is considered to be *proved* also.

This is rather perplexing, but perhaps the perplexity may be got rid of thus:—"The ground is rich *because* the trees on it are flourishing," is necessarily true, if it is also true that "wherever trees flourish, there the ground is rich;" but this general proposition must be *proved* in some way or assumed, in order that the logical conclusion may also be a true conclusion. "The trees flourish, *because* the ground is rich:" here both facts are *proved* or assumed (which for the present purpose is the same thing), and it is also affirmed by implication that "wherever trees flourish, there the ground is rich." The difference between the two sentences then is this:—the former affirms that a particular soil is rich, if soil is always rich under similar circumstances; and the reduction of the expression to the complete syllogistic form shows us what must be proved or assumed in order that the conclusion shall be true in this particular case. The latter affirms the particular thing to be true, which in the former is only true upon a certain condition; and it also affirms by implication the truth of this certain condition. The former is a syllogism, because that which is said of the whole may be said of a part. The latter is nothing more than the implicit statement of a general proposition contained in the explicit statement of a particular instance: it is no logical inference; it is no logical induction; it is simply a statement of a thing being true in a certain case, with an implicit assertion that the same thing is true in all similar cases; in other words, the form of language implicitly contains the affirmation of a general proposition, which can only be the result of an induction in the non-logical sense of that term.

The difference between logical Deduction and Induction is explained in the article INDUCTION. But it will not be out of place to say a few words on the subject here. In the Deductive Syllogism, we proceed from the whole to its parts, from the thing containing to the things or some of the things contained; and this is true notwithstanding it is not so expressed in the common form of language. For the particular conclusion, as already observed, is the thing which in ordinary language is said to be proved; but there is no demonstrative evidence to the mind, except it is shown that the particular conclusion is contained in a general proposition. The deductive syllogism as already explained shows what this general proposition is, and this general proposition is assumed to be true, or is known to be true in some other way (by induction, properly so called, for instance) than by means of the syllogism. But there is another mode of operation by which the mind can proceed from particulars to generals; but this, which may be called the Inductive Syllogism, is no syllogism, that is, no necessary conclusion, unless *all* the particulars are enumerated, or assumed to be enumerated; and in this consists the difference between the Inductive Syllogism and Induction, or what is sometimes, but, we think, not with strict propriety, called Inductive Reasoning, which however is no operation of reason, but one of the understanding only; or, to prevent disputes about terms, it is not the same mental process as that of the Logical Induction, for its conclusion is not necessary. This Induction then, which leads us from the observation of one or more like facts to make a general assertion which will comprehend like facts not observed, is a material illation of quite a different character [from the other. This process has sometimes been absurdly considered as a peculiar discovery of modern times, though it must have been practised by the first man who ever made use of his eyes. The process of investigating and collecting facts which are among the phenomena of the material world, has been greatly *improved* in modern times.

That syllogistic form which is properly called Inductive (ἐπαγωγή) is explained, though very briefly, by Aristotle (*Analyt. Prior.*, ii. 23; *Topic.*, i. 12), and is not confounded by him with the material induction of a general law or rule from the examination of a number of particular cases of a like kind.*

If we wish to prove syllogistically the mortality of a given individual John, we say—

All men are mortal;
John is a man;
Therefore John is mortal.

Now this conclusion is necessary, because "John" is contained in "all men." But suppose we wish to prove our primary proposition, that "all men are mortal," what is the process that we must follow? We may affirm mortality of all men who have died, but we cannot affirm it of all who are living and who shall live, for that is the thing to be proved. This is a case in which there can be no logical, that is, no necessary conclusion.

Dr. Whately says (p. 229) "that in the process of reasoning by which we deduce from our observation of certain known cases an inference with respect to unknown ones, we are employing a syllogism in *Barbara* with the major premiss suppressed; that being always substantially the same, as it asserts 'that whatever belongs to the individual or individuals we have examined, belongs to the whole class under which they come.'"

And he further says that induction, "so far forth as it is an *argument* (which has previously, in the same work (p. 55), been defined to be a 'syllogism when regularly expressed'), may of course be stated syllogistically; but so far forth as it is a *process of inquiry* to obtain the premises of that argument, it is of course out of the province of logic." But a syllogism will be equally good (p. 14) if we substitute arbitrary symbols for the terms, without any regard to the things signified by them; and (p. 23) "every conclusion is deduced from two other propositions or premises." This so-called induction then, stated syllogistically, turns out to be nothing different from a proper syllogism: if the premises are true, the conclusion is necessarily true. The syllogism then has done nothing, and it leaves the process of inquiry precisely where it was before the induction was put into this so-called syllogistic form.

This mistake requires a few more words, as it has been declared to be "a just, and, so far as we are aware, an original remark; and its consequences are extremely important." (*Westminster Review*, No. 17, p. 169).

The deducing an inference from facts investigated and collected is said to be an argumentative process, and, like other arguments (that is, syllogisms), capable of being syllogistically expressed. If it is a syllogistic process, it is undoubtedly susceptible of the strict syllogistic form. Now this so-called inference is the making a universal affirmation founded on a number of particulars; and if it is a syllogism, the universal affirmation is the conclusion; and if it is a syllogism, the conclusion is necessary. The conclusion is by the supposition a conclusion from certain known things as to other unknown things; and the universal conclusion is, that something is true of the unknown things which is known to be true of the known ones; in other words, that this something is true both of the known and the unknown things. Now in order to attain this syllogistic conclusion, it is said that we employ a syllogism, in which the major premiss is of this form: everything which is true of the known is true of the unknown, or everything which is true of the known is true of the known and the unknown.

To take Dr. Whately's own example:—"from an examination of the history of several tyrannies, and finding that each of them was of short duration, we conclude that the same is *likely* to be the case with all tyrannies." And it is said that in such syllogisms as these, we assume "that *whatever* belongs to the individual or individuals that we are examining belongs to the class under which they come." Now this universal affirmation is a proposition *to be proved* in some way or other. If it be assumed, it is the major of a deductive syllogism, and the conclusion is logically necessary, and also true, if the major is true.

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* *'Επαγωγὴ μὲν οὖν ἐστιν, καὶ ὁ ἐξ ἐπαγωγῆς συλλογισμὸς, τὸ διὰ τοῦ ἑτέρου θάτερον ἄκρον τῷ μέσῳ συλλογίσασθαι.*

But how is this major to be established, by virtue of which we are to have a logical illation and a true conclusion? It is admitted that in induction, properly so-called, a general material truth is to be affirmed by virtue of *particular* facts being investigated and known. But if we affirm some proposition which is more general than and comprehends that which we wish to establish, and then so construct our syllogism that the conclusion shall be a logical inference, it cannot be a true one unless we establish this more general premiss. But the object of the true induction is to establish the general truth from particular facts that are known and investigated. If, in the case supposed, the syllogism is valid, the particular facts are useless; the conclusion is logically good, and it becomes materially true when the more general proposition is established which contains the conclusion. But it is not the object of the investigation and collection of facts to establish a proposition different from and more general than that for the establishment of which the facts are investigated and collected; in other words, it is not the matter in hand to investigate and collect facts for a particular purpose, and then not to use them for that purpose.

In this so-called syllogism then we have a suppressed major of this form, "that which is true of some is true of all," which must mean either "everything which is true of some is true of all," or, "this one thing which is true of some is true of all." In the former case, the suppressed major expresses a general proposition, which we must establish in order that our illation, which is logically correct, may be true materially; but then this is not the proposition which we profess to be desirous to establish, and, more than that, it cannot be established by the facts investigated and collected. If it means that this *one thing* which is true of some is true of all, this is nothing more than to make the conclusion the major premiss, and so to conclude the conclusion from itself. It cannot be supposed that Dr. Whately has any such absurd meaning as this: but his language is capable of this meaning. He does however mean either this or the other; and it is not easy to say which is the less logical meaning of the two.

A few more words seem necessary on another passage in Dr. Whately's work, by way of clearing the way to a right comprehension of the province of logic. It has been already observed that discourse or speech generally assumes the form of a syllogism with one of the premises suppressed; which is by many modern logicians called an enthymeme.*

Dr. Whately observes that the enthymeme (the enthymeme of modern logicians) "is *not strictly syllogistic*, that is, its conclusiveness is not apparent from the mere form of the expression, without regard to the meaning of the terms; because it is from *that* we form our judgment as to the truth of the suppressed premiss. The expressed (qu. *suppressed*) premiss may be true, and yet the conclusion false." The reason here given why the (so-called) enthymeme is not strictly syllogistic is, that we form our judgment of the truth of the suppressed premiss from the meaning of the terms. This is a singular reason. The *truth* of the suppressed premiss has nothing to do with the validity of the conclusion as an inference. If the suppressed premiss were expressed, the question as to the conclusion would be, not whether the suppressed premiss were true but whether it necessitated the conclusion. If the conclusion is already made and one premiss only stated, the *truth* of the suppressed premiss is not the matter in question, but only *what* it is; and when we have ascertained what the premiss must be in order that the conclusion may be valid as an inference, we may then inquire if the suppressed premiss is true. The expressed premiss cannot be true and the conclusion false, for the proper suppressed premiss is virtually involved in the conclusion and the expressed premiss. Besides, the mere form of the expression does indicate the suppressed premiss; if it did not, the enthymeme, that is, the incomplete syllogism, the syllogism of common discourse, would be incapable of being expressed in the form of a complete syllogism. If we say A is C, *because* or *for* it is B, which is the mere *form* of the expression, we see that the suppressed premiss is, B is C, that is, B is contained in or is co-extensive with C; and every person who can comprehend the notion of a containing whole and its contained parts will understand what is meant if it is expressed in this form; A is contained in C because A is contained in B. As if a man had found that any one thing could be contained in another (second) thing, and this other (second) thing were contained in a third, he would conclude mentally that this one thing was contained in the third; and the form of his expression would be, it is contained in the third *because* it is contained in the second, in which he would tacitly suppose that the second is contained in the third, and would then necessarily conclude that the first is contained in the third.

We are now in a condition to show what are the limits of pure logic, or of a pure logic. All propositions and all syllogisms are the subject of a pure logic only so far as they have all something in common. They have only something in common so far as they are all capable of being reduced to a common form or forms; that is, a pure logic is formal only. Neither the syllogism nor its parts regard the matter, and the propositions which enter into the syllogism are only the object of logic so far as they are connected by *is* and *is not*. And since all propositions, when viewed solely as the parts of a syllogism, must be capable of being reduced to the same form or forms, it follows that all propositions as logical elements connected by *is* and *is not* are only viewed in that way in which the reason does, and must because it does, view all things which are so presented to the mind independently of the matter, namely, with relation to the notion of a containing whole and contained parts.

If this exposition seem tedious, the fault is with those who, while they profess to teach pure logic, confound it both with an applied logic and with other things also.

There seems to us another error in Dr. Whately, which is worth noticing: he says, "No conversion is employed for any logical purpose, unless it be illative;" and he adds, "the reader must not suppose from the use of the word 'illative,' that this conversion is a process of *reasoning*: it is in fact only stating the same judgment in another form." Now if we say A is B, meaning that A is contained in B, it is a logical consequence or conclusion, though not a syllogistic one, that B is not contained in A. In this case then there can be no unlimited logical conversion of the proposition. If A is co-extensive with B, then B is co-extensive with A; in which case there is a logical conversion. The laws of thought necessitate the non-conversion in the one case and the conversion in the other; and if these are not logical conclusions, there is no such thing as a pure logic or reasoning.

It is generally said that logic teaches us to reason correctly, or that it shows the process which takes place in the mind when a man does reason correctly. It is however difficult to admit the accuracy of this statement. If a man reasons at all, in the strict logical sense, he reasons correctly. Language is seldom expressed in the form of syllogisms, and it is not usual to express, in any way, both the propositions from which we deduce a conclusion. We generally express ourselves by way of a conclusion and one premiss. Now this being so, the suppressed premiss may always be discovered by somebody, though the speaker or writer may not always be able to discover his own suppressed premiss. The conclusion and one premiss being given, the suppressed premiss is also given, for the conclusion and the expressed premiss necessitate the proper suppressed premiss. They who say a man argues incorrectly, when he states a conclusion and one premiss only, *assume* that his suppressed premiss is not that suppressed premiss which the two data require, but some other. But if some other, it is impossible that they can find it out, and therefore they cannot confute him. It is only because the suppressed premiss (perhaps not known to the speaker) pointed to by the data, is the real one, that we can confute the speaker. We show what the suppressed premiss is, and then we are in a condition to dispute it, and to ask him for proof of it. A man then does reason correctly when he reasons by a conclusion and one expressed premiss. The syllogistic form shows what the premiss must be, that is, it leads to the full interpretation of the speaker's meaning. But suppose a man expresses all the terms of a syllogism, and his syllogism is vicious, is it vicious because he reasons wrong, or because he has given a meaning to some of his terms which other people do not, or has altogether mistaken them? We think that his reasoning, *as such*, is and must be correct. His apprehension may be and often is wrong. In this view, reasoning, *as reasoning*, is always correct reasoning. It has been objected to this by a friend, that many persons who are not familiar with logical considerations, on being asked whether, if every A is B, every B is also A, will admit this conversion to be true. It is then asked if, in admitting this, they reason correctly. The answer to this difficulty is furnished by the objector, who goes on to say, that if the person who admits this conversion is asked the same question as to a material conversion, such as, every goose is an animal, he immediately perceives that he cannot say every animal is a goose. This shows that his apprehension of the expression, every A is B, was incorrect, that is, he did not understand it, but took it to mean something different from what the person intended by it who put the question.

In argumentation the conclusions are the matters which are directly disputed; but the suppressed proposition is generally the real matter in dispute, or the meaning of a term is the matter in dispute. The use of logical forms consists in showing fully and explicitly what is expressed imperfectly and only implicitly in the common form of language; and its use is not a bit the less because it neither teaches to reason nor convicts our reason of error. Its use is to indicate to us all the formal elements and conditions of dependent truth. It points out to us and leads us to the consideration of the several propositions which discourse contains, and from the consideration of the several propositions it leads to the terms, and there it leaves us.

The cause of this confusion between logic and metaphysic is obvious, and lies in the necessity which all men feel of a metaphysic of some kind or other. General terms and general propositions, the elements of every material syllogism, are deeply fixed in the mind long before its consciousness is awakened to the cognisance of the operations of the reason; and in many minds this consciousness is never called into existence. Logicians clearly perceive the value of the syllogistic forms as an aid and a formal help in analysing the reasoning process in a given case: they also see or feel that the reasoning process in itself is not knowledge, but they see that it is a means to knowledge. Its barrenness in itself is confounded with its productive powers when exercised on a material, and hence they have come to confound its operating energies with its products; as if a man should confound his tools with that which is produced by his tools operating on his materials.

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* It has been observed by Sir Wm. Hamilton ('Edinburgh Review,' No. 115) that this is not the meaning of the enthymeme of Aristotle, which is quite true; nor is it the meaning of the enthymeme of Cicero. The following passages may be referred to as showing the meaning of the old enthymeme (ἐνθύμημα), which seems to have been taken by different writers in different senses: Aristotle ('Analyt. Prior.,' ii. 27): Cicero, ('Topica,' 13, 14); Demetrius Phalereus (περὶ Ἑρμηνείας, s. 30). The enthymeme of Boethius is the modern enthymeme ('Comment. in Cic.' Topic., i. c. 2.)

A pure logic will lead all men to a metaphysic, for a pure logic has its use in its applications. A metaphysic, as a system, if it does not contain a logic, will lead to the results of most systems of metaphysic, that is, to none at all.

Thus it appears that the study of logic is perhaps the proper introduction to a metaphysic; and it were much to be wished that all who have written on the latter had first been subjected to the discipline of the former.

The forms of the SYLLOGISM are considered under that article, consistently with the plan of this work. In the mean time, till we have some system of logic in our language which is founded upon and grows out of some philosophical system, it is better for the student to study only a purely formal logic, which is independent of any philosophical system, and to apply it to his various studies.

The question, What is Logic? has been a matter of much dispute. It has been disputed whether logic is a science or an art, or both—an idle question, which may be safely left undecided. It is more important to determine what is comprehended in the term logic, and this has partly been attempted here. It is also of some importance to show that the notions of this science do not appear to have been very exact among the Greeks and Romans, which may be one cause of the traditional confusion as to the limits of logic, which has been so common in modern times. It may be also useful to show what logic is conceived to be by some modern writers.

There is no definition of logic in the extant works of Aristotle; and if we deduce from his Organon, as we now have it, our notion of what the term comprehends, we shall find that it contains a great deal which does not belong to logic as it has been understood by those who have formed the most exact notions of it. If we should attempt to ascertain what logic is from the writings of all who have written on logic, it will be found impossible to form any exact notion of its limits and objects.

Dialectic is distinguished by Cicero ('Topica,' 2) from Topic. "All exact argumentation," he observes, "consists of two parts, one comprehending invention (unam inveniendi), and the other judgment (alteram judicandi)." He assigns to Aristotle pre-eminence in both, and speaks of the Stoics as having especially applied themselves to the latter, which they named Dialectic. But the dialectic of the Stoics was certainly not confined to pure logic, as appears from what Cicero says in his treatise 'On the Orator' (ii. 38), and also from the statement of the Stoical opinions as to dialectic by Diogenes Laertius, in his Life of Zeno of Citium. The Stoic dialectic seems to have comprehended logic and more, as will hereafter appear; and yet it comprehended less than the logic of the Peripatetics.*

In Dr. Whately's treatise, as may be collected from a comparison of various passages, logic seems to be convertible with syllogistic. To *reason*, in the strict sense of the word, is to make use of arguments (p. 18); an argument, when regularly expressed, is a syllogism (p. 55); and logic is the science and the art of reasoning (p. 1); from which it follows that to syllogise and to reason are convertible, and that logic is the theory of the syllogism (p. 73).† This seems to be the meaning of the author, and if such be the proper notion of logic, it must be admitted that the boundaries of the science are very limited indeed. But limited as they really are, in this view of the subject, the exercise of reducing argumentation to syllogistic forms still contains more than those may be inclined to suppose who have not been disciplined in this practice.

It may be worth while to notice what Dr. Whately says of the word *argument*. "Every argument," he observes, "consists of two parts, that which is proved, and that by means of which it is proved;" and he adds in a note, that this is the strict technical sense of the word argument, but that in popular use argument is often employed to denote the latter of these two parts alone. But this is a mistake: the popular use is the correct use, as it is in many other cases. When a man is said to use a good argument, he urges or suggests something which is either proved or universally admitted, and the goodness of his argument consists in its being applicable to the matter in hand, and obviously comprehending within it something which it is his object to establish or prove. He who argues well, possesses the inventive faculty as defined by Cicero. It is his business to establish one or more things, and to command the assent of his hearers by presenting to their minds such propositions as only need to be presented in order to command assent, and which are comprehensive enough to embrace the particular things which he has to establish. The argument, in the popular sense, is the premises of the syllogism; or it is the middle term; and it is accordingly explained by Cicero ('Topica,' 2) to be "ratio, quæ rei dubiæ faciat fidem," the *reason*, which gives credibility to a thing that is doubtful. Of course that which is proved, or to be proved, cannot be an argument within Cicero's meaning of the term. Dr. Whately himself says, "that which is used to prove the question, if stated *last* (as is often done in common discourse), is called the *reason*." But it is equally the reason whether placed first or last, and is called the *reason* with strict technical propriety, whatever may be the place which it occupies in discourse. The proper name for the syllogism is argumentation, of which the two premises are the argument; and this is the sense in which ancient logical writers understood argumentation and argument.

The meaning of the term Logic is explained by Kant with his usual clearness. Logic is the science of the laws of thought. Logic may be considered from two points of view, as General or Special. General logic comprehends only the necessary laws of thought, without which there can be no exercise of the Understanding, and it has no reference to any difference in the objects to which it is applied. Special logic comprehends the rules of thinking rightly on any given subject. General logic again is either Pure or Applied logic. In the former we abstract from all empirical conditions under which our understanding is exercised, as for instance, the influence of the senses, imagination, memory, &c. A General and Pure Logic has consequently only to deal with pure *à priori* principles, and is a canon of the Understanding and of the Reason, but only in respect to the formal part of its use; the matter which is its object may be either empirical or transcendental. A General Logic is called Applied when it has reference to the rules of the exercise of the Understanding under the subjective empirical conditions, which we learn from psychology. It has consequently empirical principles, though it is so far General that it has reference to the exercise of the understanding without any distinction of objects. In General Logic consequently, the part which comprehends the pure doctrine of the Reason must be absolutely separated from that which is Applied, though still General Logic. The first part only is properly a science, though brief and dry, as the regular exhibition of an elementary view of the Understanding must be. In this science then logicians must always bear two rules in mind:—

1. As General Logic, it abstracts from everything which the understanding contains as knowledge, and from all differences in its objects, and it has only to do with the pure form of thought.

2. As Pure Logic, it has no empirical principles, and consequently derives nothing (as has been sometimes supposed) from psychology, which therefore has no influence at all on the canon of the understanding. It is a demonstrated science, and everything in it must be absolutely *à priori* true. (Kant, 'Critik der Reinen Vernunft,' p. 55, &c., ed. 1828.)

By Applied Logic, Kant understands an exhibition of the understanding and the rules of its necessary exercise *in concreto*, namely, under those accidental conditions of the subject which may assist or impede its exercise, and all which are only empirical data. It treats of attention, its impediments and consequences, the origin of error, the state of doubt, conviction, &c.

General logic then abstracts from all our knowledge, that is, from all relation of our knowledge to an object, and contemplates only the logical form in the relation of the parts of our knowledge to one another, that is, the form of thought generally. So far as truth is concerned, since logic is conversant only about the general and necessary rules of thought, the criterion of its truth must lie in these rules; and whatever contradicts them is false, for logic would then contradict itself. Yet though a logic may be consistent, that is, not self-contradictory, yet it may be contradictory to the object; consequently the bare logical criterion of truth, namely, the conformity of knowledge with the general and formal laws of thought and of the reason, is the *conditio sine quâ non*, and consequently the negative condition of all truth. Further however logic cannot go, and any error which affects not the form, but the matter, logic has no means of detecting.

A recent German writer has viewed logic in a somewhat different light, and given it a wider range. The difficulty of presenting anything like an adequate view of the principles of Hegel by a few extracts must be the apology for this imperfect attempt; the obscurity of the exposition, if such it shall appear, may be partly though not entirely due to ourselves.

"That which is generally understood by the term logic, is viewed altogether independent of any metaphysical signification. In its present condition this science has no subject-matter (inhalt) in the sense in which subject-matter is considered as a reality and as a truth in the ordinary acceptation of the term. But it is not for this reason a formal science which is devoid of truth. The region of truth however must not be sought for in that material which people expect to find in logic, and to the want of which its unsatisfactory nature is usually attributed; but the emptiness of logical forms rather lies in the way in which they are considered and handled. So far as logical forms, considered as determinate notions, are disjointed from one another, and not bound together in organic unity, they are dead forms, and have not in them the spirit which is their living concrete unity. Thus viewed, they have no solid subject-matter (inhalt)—no matter which of itself would be a real substance (gehalt). The subject-matter which is looked for in logical forms is nothing else than a firm foundation and concretion of these abstract determinations; and such a substantial essence is usually sought for beyond the bounds of the science. But the logical reason is itself the Substantial or Real matter, which unites in itself all abstract determinations, and is their solid absolute concrete unity. There was no need then to look far for a subject-matter, as it is usually called; it is not the fault of logic if it appears empty, but it is the fault of the way of considering it."

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* See also the threefold division of Philosophy by Diogenes Laertius (*Proœmium*), into Physic (φυσικόν), Ethic (ἠθικόν), and Dialectic (διαλεκτικόν). Zeno of Elea was considered as the founder of dialectic.

† Dr. Whately says, "The third operation of the mind, namely, reasoning (or discourse) expressed in words, is *argument*; and an argument stated at *full length* and in its regular *form*, is called a syllogism; the third part of logic therefore treats of the *syllogism*." The other two parts, which are briefly treated by Dr. Whately, are—c. 1, "Of the operations of the mind and of terms;" and c. 2, "Of propositions," but they are very incomplete, and, as we think, very deficient in logical precision. There is a Supplement to c. 1.

"In forming judgments and conclusions, when the operations are especially referred to and grounded on the quantity of the notions, everything rests in an external difference, in a mere comparison, and becomes a pure analytical process and calculation void of all ideas. The deduction of the so-called rules and laws of conclusions in particular, is not much better than a handling of sticks of different lengths in order to sort them out and tie them up according to their magnitude —nothing else than the child's game of selecting and putting together the pieces of a picture which is composed of parts. This exercise of thought has accordingly not unaptly been compared with arithmetic, and arithmetic has been compared with it. In arithmetic, numbers are considered independent of any notions, as something which, independent of their equality or inequality, that is, independent of their absolute external relation, have no signification, as something which neither in themselves nor in their relations express a thought. When it is mechanically ascertained that $\frac{3}{4}$ multiplied by $\frac{2}{3}$ make $\frac{1}{2}$, this operation contains just as much and just as little thought as the ascertainment whether in a given figure this or that conclusion can be made."

Hegel remarks, that with respect to the formation of an individual mind, logic may be compared with grammar. Both logic and grammar are something different for him who first approaches them and science in general, and for him who comes back from the sciences to them. He who begins to learn grammatical forms and rules, sees in them nothing but themselves: he who has mastered a language, and compares it with other languages, is in a capacity to understand the full force of these rules and forms. Through the grammar he can reach the expression of the mind, the logic. The case is the same with a man's first introduction to logic: its signification is limited to itself. Logic must be first learned as something which a man comprehends and understands, but in which extent, depth, and further meaning are not discovered. It is not till we have a deeper acquaintance with the other sciences that the logical becomes for the mind, subjectively, not a mere abstract universal, but a universal which comprehends within it the abundance of the particular: just as the same moral maxim in the mouth of a youth, even if he understands it correctly, has not the signification and the comprehensive meaning which it has in the mind of a man of long experience, to whom the words convey the full force of the expression. Thus the logical cannot be fully estimated until it is made the result of experience in the sciences: it then presents itself to the mind as the universal truth, not as a particular knowledge coexistent with other matter and realities, but as the essence of all other knowledge.

"Logic has been defined (by Hegel) as the science of the pure thought, which has for its principium (*princip*) the pure knowledge (*wissen*); not an abstract, but a concrete living unity; and concrete in this way, that in it there are undeniably opposed to one another the consciousness of a subjective self-existence, and a second such existence, an objective; and that existence is known as a pure Notion in itself, and the pure Notion is known as the real existence. These then are the two momenta which are contained in the logical. But they are only known as existing inseparably, and not each in the consciousness as existing by itself; but it is only by virtue of their being also known as different (yet not self-existing) that their unity is not abstract, empty, and inactive, but concrete.

"This unity constitutes the logical principium (*princip*) as its element, so that the development of this difference, which is always in it, takes place *within* this element. Thus the entire notion is to be considered in the one case as existing Notion, in the other as Notion simply: in the former case it is notion by itself of reality or existence; in the latter it is notion as such, self-existing notion.

"Logic will therefore be divided into the logic of the notion as existence, and of the notion as notion; or, to make use of the common though very indefinite and ambiguous expressions, into the objective and subjective logic.

"Consistently with the fundamental element of the unity of the notion in itself, and the connected inseparability of its momenta, these momenta must be viewed also in their mutual relations, so far as they are different, and so far as the notion is considered with respect to a difference. Hence arises a sphere of Mediation (*vermittlung*), or of the notion as a system of reflective determinations, that is, of the existence passing into the internal existence of the notion, which, in this way, is not viewed as such *by itself*, but is affected by the immediate existence as by a thing properly external to itself." This is the doctrine of the essence (*wesen*), which stands between the doctrine of existence and of the notion; but in the general division of Hegel's work it is placed under the objective logic, inasmuch as, though the essence is certainly the Internal, yet the character of the subject is expressly appropriated to the Notion.

Hegel's division, therefore, is into the objective and subjective, or, more distinctly, into:—

1. The Logic of Existence (*Die Logik des Seyns*).
2. The Logic of Essence (*Die Logik des Wesens*).
3. The Logic of the Notion (*Die Logik des Begriffs*).

('Wissenschaft der Logik,' *erster band*, 1832.)

It may be useful to show in a general way what the Organon of Aristotle, as we now have it, contains. The name Organon, or Instrument, was not given by Aristotle, but is of a date posterior to him.

The following synopsis is given by Giulio Paci, in his edition of the Organon:—

Logic is conversant about the Syllogism. Accordingly the Organon explains,	**1. The Parts of a Syllogism.**	**With reference to primary Notions**		**The Categories.**
		With reference to secondary Notions		**On Interpretation.**
	2. The Syllogism.	**Generally**		**The Prior Analytica.**
		Specially.	**Demonstrative**	**The Posterior Analytica.**
			Dialectic	**The Topica.**
			Sophistic	**On Sophistic Elenchi.**

With this tabular view, the following general description of the contents of the Organon of Aristotle, by an able writer, will be intelligible. "The incorrect notions which have prevailed, and still continue to prevail, in regard to the 'nature and province of logic,' are, without detraction from his merits, mainly to be attributed to the example and authority of the philosopher himself. The books of *Categories*, as containing an objective classification of real things, is metaphysical, not logical. The two books of *Posterior Analytics*, as solely conversant about demonstrative or necessary matter, transcend the limits of the formal science; and the same is true of the eight books of *Topics*, as wholly occupied with probable matter, its accidents and applications. Even the two books of the *Prior Analytics*, in which the pure syllogism is considered, are swelled with extralogical discussions. Such for example, is the whole doctrine of modality of syllogisms, as founded on the distinction of pure, necessary, and contingent matter; the consideration of the real truth or falsehood of propositions, and the power so irrelevantly attributed to the syllogism of inferring a true conclusion from false premises; the distinction of the enthymeme through the extra formal character of its premises, as a reasoning from signs and probabilities; the physiognomic syllogism, &c. &c. The same is true of the book on *Interpretation* (περὶ Ἑρμηνείας); and matters are even worse with that on *Fallacies* (*Sophistic Elenchi*). If Aristotle, therefore, did more than any other philosopher for the progress of the science, he also did more than any other to overlay it with extraneous lumber, and to impede its development under a precise and elegant form. Many of his successors had the correctest views of the object and scope of logic; and even among the schoolmen there were minds who could have purified the science from its adventitious sediment, had they not been prevented from applying their principles to details by the implicit deference then exacted to the precept and practice of Aristotle." ('Edinburgh Review,' April, 1833.)

It may indeed be strongly suspected that the various treatises which compose the Organon contain interpolations. Further, what we now have are only a part of the logical works of Aristotle; and even this part does not exhibit simply a logical system, properly so called, but rather a system of argumentative discourse.

We may remark of the Categories that attempts have been made to found a philosophical system upon them, as explained by Aristotle. They contain, as is observed by Dr. Whately, the explicit statement that though a primary substance signifies a particular thing, as "a particular man," "a particular horse," the general term "man" or "horse" (which he calls a secondary substance) only *appears* to denote a particular thing, but in fact does not; for the thing is not one, as in the case of a "particular man," but is said of many (v. 16, ed. Pac.). This is a clear statement that general terms do not indicate realities, but are only the expression of the mode in which the mind is affected.

In the Prior Analytics it has been stated that the pure syllogism is considered: the introductory chapter of the First Book states in a general way the objects of the science as conceived by Aristotle, and is expressed with his characteristic clearness.

"It is proper," says Aristotle, "first to state about what the inquiry is, and to what the inquiry belongs, namely, demonstration and demonstrative science. Then we must define Proposition (πρότασις), Term (ὅρος), and Syllogism (συλλογισμὸς); and what is a perfect and what an imperfect syllogism. Next, what is meant by one thing being or not being in the whole of another, and what we mean by a thing being predicated of all or none. A proposition then is a sentence (λόγος) which affirms or denies something of another thing; and this either universally, or particularly, or indefinitely. By universally, I mean where it applies to all or none; by particularly, where it applies to part, or not a part, or not to all; and by indefinitely, where it applies, or does not apply, without anything being determined as to the whole or part. The demonstrative (ἀποδεικτική) proposition differs from the dialectic (διαλεκτική). The demonstrative is an assumption of one side of the question, namely the contradiction; for he who demonstrates does not interrogate, but he assumes; but the dialectic is an interrogation as to the contradiction.* This, however, makes no difference with respect to the syllogism in either case, for both he who demonstrates and he who interrogates syllogise by assuming something to be predicated or not to be predicated of another thing. Consequently a syllogistic proposition will be simply an affirmation or denial of one thing with respect to another, in the way already mentioned; and a proposition will be demonstrative if it is true, and obtained by means of the original hypothesis. A dialectic proposition is, with respect to the question, an interrogation about denial; but to him who syllogises, it is the assumption of that which is apparent and probable, as it is shown in the Topica. What then is a proposition, and in what respect a syllogistic, demonstrative, and dialectic proposition differ, will be accurately stated in what follows (in the 'Analytica Posteriora'); but for the present purpose what has been already said is sufficient.

"I call Term that into which a proposition is resolved, as the predicate (τὸ κατηγορούμενον), and that of which predication is made, with the addition or not of 'being,' or 'not being.' A syllogism is discourse, in which certain things being laid down, something different from these things necessarily results by virtue of these premises (τῶ ταῦτα εἶναι). And I mean by the words 'by virtue of the premises,' that this something results by reason of them (διὰ ταῦτα): and 'by reason of them' means that no other term is needed in order to this necessary result. Now, I call that a perfect syllogism which requires nothing else besides what is assumed or granted in order that the necessary conclusion may appear. I call that an imperfect syllogism which requires one or more things which are of necessity by virtue of the given terms, but are not assumed in the propositions. For one thing to be said to be in the whole of another, and one thing to be predicated of the whole of another, is the same thing; and I mean by predication of the whole of a thing, when one cannot conceive any part of the one thing (the subject) of which the other cannot be predicated; and the like when the predication is of no part of a thing."

It was apparently the object of Aristotle in his so-called logical treatises, as we now have them, to make a perfect system of argumentative discourse, and not merely a logical (properly so called) system. It is probable that if all his works of this class were extant and arranged according to his own method, we should see still more clearly that the whole was not considered a logical system (as the term logic is strictly understood), but that a logical system (as the term is strictly understood) was contained in it. Whether Aristotle or any other person put the existing books of the Organon together, neither the author who conceived them in connection with one another, nor any one else, considered them as forming a pure logical or even a pure dialectic treatise, but a treatise on argumentation. And this is clear enough from an examination of the contents of the Organon, and the remarks of Cicero (*Topica*) and his commentator Boethius, who was himself a writer on logic. Boethius, who uses the term *Logic*, informs us that the Peripatetics understood this term as Cicero understood it, and Cicero defines it to be "disserendi diligens ratio," or "an exact method of argumentation." The Peripatetics, he adds, understood logic to consist in invention and judgment; but the Stoics, who neglected invention, considered it to consist in judgment only, which they distinguished by the name of dialectic. Thus the logic of the Peripatetics was larger than the logic of the Stoics. The logic of the Peripatetics consisted, first of topic or invention, which teaches the method of easily discovering arguments; and Boethius remarks that Aristotle in his 'Topica' treats of the "maximæ propositiones" (called *loci*), which are universal propositions, of undoubted truth, which need no demonstration, or probable propositions, and from which we descend to the conclusions of the syllogism. Judgment is more particularly exercised in making conclusions (in colligendi ratione), but inasmuch as all argumentation and syllogising depend on and are constructed of propositions, we have to consider both the matter of propositions and their connection. As to the *matter*, we have to consider whether the propositions are true, or necessary, or probable, or sophistical. As to the connection, we have to consider the union and the composition of the propositions, which may be called the *form* of the arguments. Logic then consists of invention, and of the conclusions from invention, or the form of the argumentation. The part which treats of invention supplies the instruments or means for invention, and, as already observed, is called Topice. The part which relates to judgment supplies certain rules for discerning or separating (*discernendi*), and is called Analytice: so far as it treats of the connection or union of propositions, it is called Analytice Prior; so far as it treats of the inventions themselves, it is called Analytice Posterior, when it is engaged about discerning necessary arguments; but when it is engaged about false and deceptive arguments (*cavillatoria*), that is, sophistical, it is called the Elenchi. Boethius then concludes that Aristotle treated of logic in a more complete manner than the Stoics, "since he treated of the two things besides which there is no third, namely, invention and judgment, while the Stoics neglected invention and only furnished us with the instruments of judgment."

This statement of what the logic of Aristotle was, may help to remove certain long-rooted mistakes on the matter. Dr. Whately, who confines logic to the pure syllogism in his theoretical view of the subject, though not in his practical exposition of it, says that "with the exception of Aristotle, hardly a writer on logic can be mentioned who has clearly perceived, and steadily kept in view throughout, its real nature and object." And he remarks that even Aristotle is not *entirely* exempt from the error of mistaking the nature of logic, and extending it to subjects with which it has no proper connection. Now the fact is that Aristotle's logic, being what we have here explained it to be, is a very different thing from what it appears to be considered to be by many. To say that Aristotle is *not entirely* exempt from the error above mentioned is rather a singular expression, when three-fourths of his Organon have nothing at all to do with the pure syllogism. In fact Aristotle's Organon, and his logic as explained by Boethius, are much more like Watts's much-abused 'Right Use of Reason' than like what many modern writers take them to be.

There is a short but not a satisfactory account of the contents of Aristotle's Organon by Dr. Thomas Reid, Edinburgh, 1806. It may however serve to give the reader some notion of the contents of the work. The best account of it is said to be by Barthélemy St. Hilaire, 'La Logique d'Aristote,' 2 vols. 8vo. [LOGIC.]

The controversial tone of this article, in a work of this description, may require a word or two of apology. Until the limits of logic are better defined, the subject must be controversial, for the question "What is Logic?" must continually recur. The work with reference to which these remarks are chiefly made has long had a great circulation, and has taken the place of former treatises, which is a sufficient reason why the errors of that work, if such they be, should be pointed out. In various parts of his work, Dr. Whately has explained with sufficient precision what he considers Logic to be: he has in fact defined it as the pure syllogism, irrespective of all material considerations. But in the execution of his plan he continually perplexes the reader with considerations as to the matter of propositions and terms; and he transcends the narrow limits within which the science, as he understands it, is confined. It cannot be supposed that a writer, however able, can so far deviate from a scientific method without serious prejudice to his work.*

Two reviews of Dr. Whately's treatise have fallen under our notice, one of which appeared in the 'Westminster Review' for January, 1828; the other in the 'Edinburgh Review' for April, 1833. The former shows that Dr. Whately is not alone in some of those opinions which we consider erroneous. The latter is from a master-hand [Sir W. Hamilton], who is well acquainted with both ancient and modern writers on logic and philosophy. To this article we are much and deeply indebted.

Several treatises on logic have appeared in Germany, which profess to exhibit the subject according to a strictly scientific method. Among these may be mentioned Kiesewetter's 'Grundriss einer Allgemeinen Logik nach Kantischen Grundsätzen,' &c., Berlin, 1791.

A complete catalogue of logical treatises would be very long; and the value of the catalogue would hardly compensate for its length. Writers have formed their notions of the science with more or less precision, but have seldom, if ever, kept within their own limits; and this is a difficulty which is inherent in the subject. If confined to the bare affirmation or negation of propositions expressed by *is* or *is not* (considered simply as determinations of quantity), and to the pure syllogism, the theory of logic is soon exhausted, and as a science it is comprised within very narrow limits. If we once transcend those bounds, we enter into a wider sphere, in which this formal logic becomes a mere point. To ascertain the full import of the words *is* and *is not* in a proposition is the highest aim of philosophy.

A student in logic, consulting only modern works, may be debarred from even the slightest notion of an historical view of the subject, by the mixture which his books give him of the ideas of writers of all times and countries. To disentangle the confusion of minds and methods which even a good treatise presents, *historically* speaking, it is above all things necessary that he should first get some knowledge of what Aristotle is. And this the work of an erudite and acute German writer enables us to give in a very useful way.

The 'Elementa Logices Aristotelicae,' by Professor Trendelenburg, Berlin, 1842, 2nd edition, consists of passages selected from the works of Aristotle, which passages may be considered as containing the elements of the science. These passages are so arranged as to present a kind of outline of the whole logical system of Aristotle. They are intended for the use of the higher classes in gymnasia, and as a preparation for philosophical studies.

The following article is simply a translation of these extracts, which are retained in the order given to them by Trendelenburg; and the references to the original places in Aristotle have also been retained. The original terms of Aristotle are also given in brackets the first time that each is mentioned.

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* *Τὴν διαλεκτικὴν ἐπιστήμην οὖσαν τοῦ ὀρθῶς διαλέγεσθαι περὶ τῶν ἐν ἐρωτήσει καὶ ἀκοκρίσει λόγων.* (Diog. Laert., 'Zeno,' vii., c. 84.)

* The edition of Dr. Whately's 'Logic,' referred to in this article is the fourth. The writer [1840] did not know that there was a sixth, which contains some few alterations, till this article was ready for the press. The reader should refer both to the fourth and to the sixth editions.

In the preface to another useful work ('Erläuterungen zu den Elementen der Aristotelischen Logik,' Berlin, 1842, by the same author), he has more fully explained his views in making these extracts from Aristotle, and the following remarks are his:—At the time of the Reformation Luther saw clearly the advantage of logical instruction in the higher schools, and he viewed it correctly as the completion of the grammatical instruction. The circle of studies in modern times has been wonderfully enlarged, and it has been found necessary to extend the school instruction to meet the wants of the present age. But the great variety of subjects with which our present systems of education occupy us, only render it the more necessary to discipline the mind in such a manner that it shall see a unity in all that is presented to it, and not be bewildered by the variety of objects whose connection escapes us, when they are contemplated separately. Such a discipline is furnished by a good course of elementary instruction in logic. For this purpose the author has adopted the genuine words of Aristotle, in which the philosopher has laid down his elementary logical principles. The logic of Aristotle is not antiquated, though it is both misunderstood by some, and blamed by others who do understand it. It is not the formal logic of Kant, which would confine us to the forms of thought without any reference to the object into which the thought penetrates. Such a limitation of the subject is entirely at variance with the system of Aristotle, and opposed to its real character. "We have," says Trendelenburg, "attempted to restore this real character, and thus brought Aristotle nearer to the objective demands of modern times." Those who view logic as purely formal, view it differently from Aristotle, and they may consider their mode of viewing the subject to be better than his. Those who say that Aristotle has, in some matters, erroneously extended the province of logic to things beyond its limits, and has not always kept close to the real subject, appear to have conceived that he viewed it merely as formal, and sometimes transgressed the boundaries of the science which he recognised. This is however an erroneous view of Aristotle's system.

The advantage of studying these elementary principles in the words of Aristotle is, that in his writings the language of philosophy is formed into a scientific terminology, which is the basis of that which we now use. We cannot therefore lay a sure foundation for our logical and philosophical studies on any other basis than a full comprehension of the meaning of Aristotle's terms.

The author remarks that a learner of logic there meets with those fundamental notions (begriffe) in their simple nakedness, which lie hidden in all our knowledge and govern it. As these notions are hid or concealed in our knowledge, they appear dry and lifeless when they are produced in their naked form. It is therefore the business of the teacher to show to the pupil their real significance, to make him see their actual value in their application. Now the instruction in the German Gymnasia, as in the higher schools in Great Britain and Ireland, is in the learned languages and in mathematics; and accordingly the teachers in both these departments, if they are to make use of such a work as Trendelenburg's, must be able to apply logical principles to instruction in language and in mathematics. To facilitate this method of instruction is the object of the learned author in the 'Illustrations (Erläuterungen) to the Elements of Aristotle,' not, as he modestly observes, that this is precisely the form in which he supposes that they ought to be presented to the pupil, but "merely to render clear the fundamental notion of the logical relationship in the objects of scientific observation."

The mode in which the author suggests that his two works should be used is probably the best; but they cannot be used at all in ordinary instruction, except under the guidance of a competent teacher. They will however be useful to those who have a competent knowledge of the Greek and German languages, and possess some elementary notions of logic; and those who cannot read Greek with facility will probably find the following translation sufficiently exact to give them the meaning of Aristotle. A translation of such extracts is not easy, and it is possible that there may be some errors in it. A careful study of these extracts however will convince a student how meagre and unsatisfactory an exhibition of the elementary principles of logic even our best works on the subject contain.

Outlines of Logic.

(1.) In things in which there is both falsehood and truth, there is a composition of ideas as though they were one. ('De Anim.,' iii. 6.) For falsehood and truth are concerned with composition and separation. Accordingly nouns and verbs by themselves resemble the idea without composition and separation, as "man" or "white," when nothing is added: for there is so far neither falsehood nor truth. ('De Interpret.') Consequently he thinks truly who considers that which is separated to be separated, and that which is compounded to be compounded; but he thinks falsely whose thoughts have a different relation from that which the things have. ('Metaph.,' ix. 10.)

(2.) All speech (λόγος) is significative, but not all enunciative (ἀποφαντικός), but only that in which there is either truth or falsehood. But it is not in all; for example, prayer is speech, but neither true nor false. The enunciative alone belongs to the present inquiry. ('De Interpret.,' c. 4.)

(3.) Of things said with no connection, each signifies either substance (οὐσία) or quantity, or quality, or relation, or where (space), or when (time), or position, or possession, or acting, or being acted on. And substance (οὐσία) is, to give an example, such as man, horse: and quantity is, such as two cubits, three cubits: and quality, such as white, grammatical: and relation, such as double, half, greater: and where, such as in the Lyceum, in the agora: and when, such as yesterday, last year: position, such as he is lying, he is sitting: and possession, such as he has shoes on, he is armed: and acting, such as he cuts, he burns: and being acted on (πάσχειν), such as he is cut, he is burnt. ('Categ.,' c. 4.)

(4.) Simple enunciative speech is firstly an affirmation, secondly a negation. And affirmation (κατάφασις) is an enunciation of something towards another thing; and negation (ἀπόφασις) is the enunciation of something away from another thing. And the speech is true in like manner as the things are true. ('De Interpret.' c. 5, 6, 9.)

(5.) "Not-man" is not a noun; for indeed there is no name to call it by; for it is neither affirmative speech nor a negation. But let it be called "name or noun indefinite," (ἀόριστος) because it can be said equally of anything, both of what is and what is not.

Every affirmation and negation will consist either of a noun and a verb or of an indefinite noun and a verb. But without a verb there is neither affirmation nor negation. ('De Interpret.,' c. 2, 10.)

(6.) Of things some are universal and some particular. I call that universal (καθόλου) which can be said of more things (than one); and I call that particular (καθ' ἕκαστον) which cannot: thus, man belongs to the universal, and Callias to the particular. ('De Interpret.,' c. 7.) A Proposition (πρότασις) then is speech either affirming or denying something about something. And this speech is either universal or particular (ἐν μέρει), or indefinite (ἀδιόριστος). I call that universal which belongs either to all or to none; I call that particular which belongs either to some one, or not to some one, or not to all; and I call that indefinite which either belongs or does not belong, without the universal or particular, as, for instance, of opposite things that there is the same science, or that pleasure is not a good. ('Analyt. Pr.,' i. 1.)

It is very evident that the universal is more efficient, because, knowing the first of two propositions, we know in a manner the second also, and have it potentially; for example, if a man knows that the angles of every triangle are together equal to two right angles, he knows in a way that the angles of an isosceles triangle also are together equal to two right angles potentially (δυνάμει), even if he does not know that the isosceles triangle is a triangle. But he who knows this proposition (the second) by no means knows the universal, either potentially or in reality (ἐνεργείᾳ). And the universal is an object of the intellect; but the particular terminates in the sensuous perception. ('Analyt. Post.,' i. 24.)

(7.) Every proposition belongs either to what is, or to what must be, or to what can be. ('Analyt. Pr.' i. 2.)

(8.) Of all things indeed which exist there are some of such a kind that they can be predicated with truth universally of nothing else, such as Cleon, Callias, and a single thing, and what is an object of sense; but of these things others can be predicated (for each of these persons is both man and animal); and some things are themselves predicated of other things, but of them there is no further predication by other things; and some are both themselves predicated of others, and others of them, for example, "man" is predicated of "Callias,' and "animal" of "man." Accordingly that there are some things which exist which cannot be predicated of anything is manifest. For of sensuous objects nearly every one is such that it can be predicated (κατηγορεῖσθαι) of nothing. ('Anal. Pr.' i. 27.)

The genera (γένη) are predicated of the species, but not the converse the species (εἴδη) of the genera. ('Categ.' c. 5.)

(9.) It is impossible for the same thing at the same time to belong (ὑπάρχειν) and not to belong to the same thing and in the same manner. This indeed of all principles is the most certain; for it is impossible for any one to conceive that the same thing is and is not. Wherefore all who demonstrate, carry back (their demonstration) to this ultimate notion. ('Metaphys.' iv. 3.)

Every thing which is true must agree with itself in every way: for with truth all which is true is in harmony, but with falsehood the truth is soon at variance. ('Eth. Nic.' i. 8.)

(10.) And since it is possible for what belongs to be enunciated as not belonging, and what does not as belonging, and what belongs as belonging, and what does not belong as not belonging, and with respect to other times than the present in like manner, it is possible to deny both all that a man has affirmed, and to affirm what he has denied. So that it is manifest that to every affirmation a negation is opposed, and to every negation an affirmation; and let the contradiction (ἀντίφασις) be this, affirmations and negations opposed.

And I call opposition (ἀντικεῖσθαι) the contradiction of the same thing about the same thing, but not ὁμωνύμως. (Comp. 'Categ.,' c. 1; 'De Interpret.,' c. 6.)

Contradiction is opposition (ἀντίθεσις) in which there is no mean in itself. And as parts of contradiction, there is on one side affirming something of something, and on the other side denying something from (ἀπό) something. (‘Analyt. Post.,’ i. 2.)

In affirmation and negation always, whether it is a thing that exists or does not exist, the one will be false and the other true: for of the two that Socrates is sick and that Socrates is not sick, when Socrates exists, it is manifest that one of them is true and the other false, and if he does not exist in the same manner: for that he is sick, when he does not exist, is false, and that he is not sick is true.

Accordingly, to these things alone, which are opposed as affirmation and negation, it will be peculiar for one of them always to be true or false. (‘Categ.,’ c. 10.)

(11.) Things included in the same genus which differ most from one another, are defined to be contrary (ἐνάντια). (‘Categ.,’ c. 6.)

(12.) Therefore I say that affirmation is opposed to negation in the way of contradiction, when the one signifies that a thing is universal and the other signifies that the same is not universal: as for example, every man is white—not every man is white; no man is white—a certain man is white. And I say that the universal affirmation and negation are opposed as contraries: as for example, every man is white—no man is white; every man is just—no man is just. Therefore it is not possible for these to be true at the same time. (‘De Interpret.,’ c. 7.)

(13.) And I say that propositions opposed are in common expression (κατὰ λέξιν) four—namely, all and none, all and not all, some and none, some and not some; but in truth three; for some is opposed to not some merely in expression. And of these three propositions the universal, all and none, are contrary: for example, all knowledge is excellent, no knowledge is excellent; but the other propositions are opposed (as contradictory). (‘Analyt. Pr.,’ ii. 15.)

(14.) And since every proposition is either of being or of necessarily being or of the possibility of being, and of these some are affirmative and some negative in every mode, and again of the affirmative and negative propositions some are universal and some particular and some indefinite, of necessity the proposition which is universally negative can be converted (ἀντιστρέφει) in its terms (ὅροι): for example, if no pleasure is a good thing, neither is any good thing pleasure; but the affirmative proposition must be converted, not indeed universally but particularly; thus if all pleasure is good, some good also is pleasure. And of particular propositions the affirmative proposition must be converted particularly, for if some pleasure is good, some good also is pleasure: but as to the negative, it is not of necessity, for, if "man" does not belong to (cannot be predicated of) some animal, it does not follow that "animal" cannot be predicated of "some man." (‘Analyt. Pr.,’ i. 2.)

(15.) The things which are sought are equal in number to the things which we know. And we seek four things—the That, the Why, If it is, What it is. (τὸ ὅτι, τὸ διότι, εἰ ἔστι, τί ἐστίν.) For when we seek whether this or that is, referring it to number, for example, whether the sun is eclipsed or not, we seek the That. And there is proof of this; for when we have found out That it is eclipsed, we cease inquiring; and if from the beginning we know That it is eclipsed, we do not inquire whether it is. And when we know that it is, we inquire the Why: for example, when we know that the sun is eclipsed, and that the earth moves, we inquire Why the sun is eclipsed, or Why the earth moves. These things accordingly we inquire after thus; but some things we inquire after in another manner, as for example, Whether there is or is not Centaur or God. I simply mean if there is or is not, but not if he is white or not. And when we know that there is, we inquire What it is, for example, What is God or what is man. (‘Analyt. Post.,’ ii. 1.)

(16.) To know That a thing is and to know Why it is are different; and the knowledge of the Why refers to the first cause. The chiefest of knowledge is to contemplate the Why. (‘Analyt. Post.,’ i. 13, 14.)

(17.) And we think that we know each thing simply when we think that we both know the cause by which the thing is, that it is its cause, and that it cannot be otherwise. (‘Analyt. Post.,’ i. 2.)

(18.) All instruction and all rational learning come from knowledge preceding. And this is manifest to them who contemplate all (sciences); for both those of the sciences which are mathematical by these means exist, and every one of the other arts. (‘Analyt. Post.,’ i. 1.)

(19.) And things are prior and better known in two ways: for it is not the same thing to be prior by nature and prior as regards us, nor yet to be more known by nature and more known by us. And I call those things prior and more known as regards us which are nearer the sense, but I call simply prior and more known those things which are farther from the perception. And the farthest off are the most universal, and the nearest are the particular. (‘Analyt. Post.,’ i. 2.)

(20.) We get certainty in all things either by syllogism (συλλογισμός) or by induction (ἐπαγωγή). (‘Analyt. Pr.,’ ii. 23.)

We learn either by induction or demonstration (ἀπόδειξις); and demonstration proceeds from the general, but induction from the particular. (‘Analyt. Post.,’ i. 18.)

(21.) And syllogism is speech, in which when some things are laid down, something else different from what are laid down results by virtue of their being laid down; and by virtue of their being laid down I mean that it results through them; and I mean by resulting through them, that there is no need of any external term for the necessity to be. (‘Analyt. Pr.,’ i. 1.)

(22.) And I call Term that into which the proposition is resolved, as the predicate and the thing of which it is predicated (subject). (‘Analyt. Pr.,’ i. 1.)

(23.) Whatsoever is affirmed of the predicate (τοῦ κατηγορουμένου), will be affirmed of the subject (τοῦ ὑποκειμένου) also. (‘Categ.,’ c. 5.)

(24.) When three terms are so related to one another that the last is in the whole of the middle, and the middle is either in or not in the whole of the first, of necessity there is a perfect syllogism of the extremes. And I call middle (μέσον) that which is both itself in another and another in it, and which also by position becomes middle: And I call extremes (ἄκρα) both that which is in another, and in which another is. For if A can be predicated of all B, and B of all C, necessarily A can be predicated of all C. And I call a figure (σχῆμα) of such description the first. (‘Analyt. Pr.,’ i. 4.)

(25.) And when the same thing belongs to all of one thing and to none of another, or to all or none of each, such a figure I call the second, and that which is predicated of both I call the middle term in it—And the middle term is placed without the extremes, but the first in position—And a syllogism will be possible both when the terms are universal and when they are not universal. When they are universal, there will be a syllogism, when the middle is in all of one, and in none of the other, if the negative be in one of the two terms: but otherwise the syllogism cannot be.

For let M be predicated of no part of N, but of all X. Since then the negative proposition can be converted, N will belong to no part of M: but M by the supposition was predicated of all X. Accordingly N will be no part of X: for this has been shown before. Again, if M shall belong to all N, but to no part of X, neither will N belong to any part of X: for if M belongs to no part of X, neither will X belong to any part of M: but M by the supposition belongs to all N. Therefore X will belong to no part of N: for this also has become the first figure. And since the negative proposition is convertible, (ἀντιστρέφει) neither will N belong to any part of X, so that there will be the same syllogism. An affirmative syllogism is not produced by means of this figure, but they are all negative, both the universal syllogisms and the particular syllogisms. (‘Analyt.’ i. 5.)

(26.) But if one thing belongs to the whole of the same thing and another belongs to no part of it, or both to the whole or to no part, such a figure I call the third; and I call that the middle in it of which both the predications are made, and I call the extremes the predicates: —And the middle is placed without the extremes, and last in position —And a syllogism will be possible both when the terms are universal and when not universal with reference to the middle.

Accordingly if they are universal, when both P and R belong to all S, P will belong to some part of R of necessity: for since the affirmative is convertible, S will belong to some part of R, so that since P belongs to all of S, and S to some part of R, of necessity P belongs to some part of R: for the syllogism is produced by means of the first figure.

To form a syllogism universally by means of this figure is not possible, neither in the negative nor in the affirmative. (‘Analyt. Pr.,’ i. 6.)

(27.) And it is manifest that every demonstration will be by means of three terms and not more. And since this is clear, it is manifest that it consists of two propositions and not more: for the three terms are two propositions. (‘Analyt. Pr.,’ i. 25.)

(28.) It is necessary in all the figures that the middle be in both the propositions. If then the middle term both predicate and be the subject of predication, or itself predicates and anything is denied of it, it will be the first figure: but if it both predicates and is denied of something, it will be the middle figure: and if other things are predicated of it, or one thing is denied and another predicated, it will be the last figure. (‘Analyt. Pr.,’ i. 32.)

(29.) Moreover in all syllogisms one of the terms must be affirmative and it must be universal: for without the universal there will either be no syllogism, or it will not relate to the thing proposed, or the very thing to be proved will be assumed. For let it be proposed to prove that music is an honourable pleasure; if then any one should assume that pleasure is honourable without adding the "all," it will not be a syllogism: and if he should assume that some pleasure is excellent, if he means other pleasure, it has nothing to do with the subject proposed, and if he means the very pleasure itself, he assumes the very thing which is to be proved. (‘Analyt. Pr.,’ i. 24.)

(30.) The science of what a thing is, it is possible to investigate by means of this figure alone (the first). For in the middle figure the syllogism is not affirmative, and (the question) what science is, requires the affirmative: and in the last figure there is a syllogism, but not a universal syllogism, and the question what a thing is, belongs to the universal. (‘Analyt. Post.,’ i. 14.)

(31.) All who attempt to syllogise from things less credible than the conclusion, manifestly do not syllogise rightly. (‘Top.,’ viii. 6.)

(32.) From what is true it is not possible to form a false conclusion, but from what is false it is possible to form a true conclusion; not however "why" but "that" the thing is. (‘Analyt. Pr.,’ ii. 2. Accordingly it is manifest that, if the conclusion be false, of necessity those things are false either wholly or partly from which the argumentation (λόγος) is derived; but when the conclusion is true, it is not a matter of necessity for either anything or all to be true, but it is possible when none of the things in the syllogism are true, for the conclusion to be true notwithstanding, but not as a matter of necessity. And the reason is, that, when two things are so related to one another, that when one is, of necessity the other is, when this other is not, neither will the first be, but when it is, it is not a matter of necessity that the first be. ('Analyt. Pr.,' ii. 4.)

(33.) And a Philosophema is a syllogism demonstrative, and an Epicheirema a syllogism dialectic, and a Sophisma a syllogism contentious, and an Aporema a dialectic syllogism of contradiction. ('Top.,' viii. 11.) Demonstration then is, when from true and first things the syllogism comes, or from things of such a kind which by means of some first and true things have received the beginning of the knowledge concerning them: and a Dialectic syllogism is that syllogism which is derived from common notions. ('Top.,' i. 1.)

And speech is called false in one manner, when it appears to be conclusive but is not conclusive, which is called a contentious syllogism (*ἐριστικὸς συλλογισμός*). ('Top.,' viii. 12.)

Contentious speech is the syllogising from notions that appear to be common notions, but are not; or it is merely apparent syllogising. ('Soph. Elench.,' 2.)

The equality of opposite arguments (*λογισμοί*) would appear to be productive of doubt. ('Top.,' vi. 5.)

(34.) Induction (*ἐπαγωγή*) is the progress from the particular to the universal: thus if a pilot who is skilled is the best, and if a charioteer who is skilled is so, universally also the person who is skilled in each thing is the best. And induction is the more persuasive and more clear, and more intelligible to sense, and in vogue among the many; but the syllogism has more force and is more effective against opponents in argument. ('Top.,' i. 12.)

(35.) Induction then and the syllogism from induction, is through one extreme to syllogise the other with the middle term; for example, if B is the middle term of A and C, by means of C to show that A may be predicated of B: for thus we make inductions.—But C must be considered as composed of all things individually: for induction is made through all. ('Analyt. Pr.,' ii. 23.)

(36.) In a manner induction is opposed to syllogism; for the one (syllogism) by means of the middle term proves the first term to be predicated of the third, but the other (induction), by means of the third term, proves the first to be predicated of the middle term. Naturally then the syllogism through the middle term is prior and more familiar; but to us the syllogism through induction is the clearer. ('Analyt. Pr.,' ii. 23.)

(37.) Probable (*εἰκός*) and Sign (*σημεῖον*) are not the same, but Probable is a proposition conformable to opinion: for what for the most part men know to be produced in a particular way or not produced, or to be or not to be, this is probable; for example, that men hate the envious, or like those who love. And Sign must be considered to be a proposition demonstrative either necessary or conformable to opinion: for if when anything is, the thing is, or when anything has happened, the thing happens before or after, this is a sign of the thing having happened or being.

Enthymema then (*ἐνθύμημα*) is a syllogism from probables or signs. ('Analyt. Pr.,' ii. 27.)

(38.) And an example is, when the first is shown to belong (*ὑπάρχον*) to the middle through one like the third. But it must be known that both the middle belongs to the third and the first to the like. For example, let A be bad, and B be to take up war against neighbours; and C, the Athenians, taking up war against the Thebans; and D, the Thebans, taking up war against the Phocians. If then we wish to show that to make war on the Thebans is a bad thing, we must assume that to make war on neighbours is bad. And the evidence of this is from the like things, for example, that the war of the Thebans against the Phocians is bad. Since then to make war on neighbours is bad, and since the war against the Thebans is against neighbours, it is manifest that to war against the Thebans is bad. Accordingly it is clear that B belongs to C and to D (for both C and D are to take up war against neighbours), and that A belongs to D (for the war of the Thebans against the Phocians was not good); but that A belongs to B will be shown through D.

And in the same manner also if through more like things, the evidence should exist of the middle belonging to the first. Accordingly it is manifest that the example is neither as a part to the whole, nor as a whole to a part, but as a part to a part, when both are included in the same notion, and the one is known. And it differs from induction, inasmuch as induction by means of all the particulars shows that the first belongs to the middle, and does not connect the syllogism with the first, but the example both connects it and does not derive its evidence from all the particulars. ('Analyt. Pr.,' ii. 24.)

(39. Both modes of proof, that by syllogisms and that by induction, teach by means of things known before; the one taking its assumptions from the general notions of mankind, and the other showing the universal through the evidence of the particular. And in the same manner rhetorical arguments persuade; for they (the arguments) are either by means of example, which is induction, or by means of enthymemata, which is syllogism. ('Analyt. Post.,' i. 1.)

(40.) Refutation (*ἔλεγχος*) is a syllogism of contradiction. ('Analyt. Pr.,' ii. 20.)

(41.) And objection (*ἔνστασις*) is a proposition contrary to a proposition. And it differs from the proposition, in as much as it is possible for the objection to be particular, but the proposition either cannot be so at all, or at least not in the universal syllogisms. ('Analyt. Pr.,' ii. 26.)

(42.) Since it is the nature of some things through themselves to be known, and of some through other things (for principles (*ἀρχαί*) are known through themselves, but other things subordinate to principles are known through other things), when any one attempts to show through itself a thing not known through itself, then the thing to be proved (*τὸ ἐξ ἀρχῆς*) is assumed. ('Analyt. Pr.,' ii. 16.)

And people appear to assume what is to be proved in five ways. Most manifestly and first, if a person should assume that which requires to be proved. And this in itself does not easily escape notice; but in common names (*συνώνυμα*),* and in all those things in which the name and the notion (*λόγος*) have the same meaning, it is more easy to escape detection. And the second way is when a person assumes the universal when it is necessary to prove the particular; for example, if a person attempting to show that of contrary things (*ἐνάντια*) there is one science, should universally assume that of opposed things (*ἀντικειμένα*) there is one science; for he appears to assume with many other things that which it was requisite to prove by itself. The third way is, if any one, when the thing proposed is to show the universal should assume the particular; for example, if he had to prove that of all contrary things there is one science, he should assume that there is one science of some particular contrary things; for such a one also appears to assume separately by itself that which it was requisite to prove together with others. Again, if any one should assume the problem (*τὸ προβληθέν*) by dividing it; for example, if, when it was required to show that the art of medicine concerned both health and sickness, he should assume each separately. Or if any one should assume one of two things which follow one another of necessity; for example, that the side (of a square) has no common measure with the diagonal, when it was required to show that the diagonal has no common measure with the side. ('Top.,' viii. 13.)

(43.) The affirmative (demonstration) is prior to the negative, and more easily known, for through the affirmation the negation is known, and the affirmation is prior, as being also is prior to not being. Further, it is nearer to a first principle; for without the positive proof there is no negative proof. ('Analyt. Post.,' i. 25.)

(44.) All persons who form a conclusion through that which is impossible, form indeed a false conclusion, but they show what has to be demonstrated by virtue of an hypothesis, when anything impossible results by the assumption of the contradiction (*ἀντίφασις*) (10). ('Analyt. Pr.,' i. 23.)

The demonstration which leads to an impossibility is thus:—If it were required to show that A does not belong (*ὑπάρχει*) to B, it must be assumed that it does, and that B belongs to C, so that it follows that A belongs to C. But let this (that A belongs to C) be known and agreed to be impossible. Then it is not possible for A to belong to B. If then it is granted that B belongs to C, it is impossible for A to belong to B. And since the affirmative (*κατηγορική*) demonstrative is better than the negative, it is manifest that it is also better than the demonstrative which leads to impossibility. ('Analyt. Post.,' i. 26.)

(45.) The object of science and science differ from the object of opinion and opinion, inasmuch as science is universal and is of necessity, and the necessary can not be otherwise, but opinion is unsettled. ('Analyt. Post.,' i. 33.)

(46.) Induction is not possible when there is no sensuous perception; for sensuous perception belongs to the particular. Nor yet through sense nor through perception is it possible to attain science. For though sensuous perception refers to a thing as being of a certain quality, and not to any definite thing, nevertheless it is necessary to have some one definite thing as the sensuous object, and the where and the when. But what is universal and in all things it is impossible to have sensuous perception of, for it is neither any particular thing nor now; for, if it were, it would not be universal; for we affirm that the always and the everywhere are universal. Wherefore, also, if we were in the moon and saw the earth intercepting (the light of the sun), we should not know the cause of the eclipse; for we should perceive that it is eclipsed now, but we should not know why at all, for there would be no sensuous perception of the universal. ('Analyt. Post.,' i. 18, 31.)

(47.) And I call universal whatever belongs to all both of itself and in itself. It is manifest, then, that whatever is universal of necessity belongs to the things. And the "of itself" and "in itself" are the same; for example, of itself a point belongs to a line inasmuch as it is a line; and to a triangle, inasmuch as it is a triangle, there belong two right angles; for of itself the triangle (as to angles) is equal to two right angles. And the universal then is, when it can be demonstrated of any individual (of the class) and of no class prior to that. ('Analyt. Post.,' i. 4.)

(48.) To what thing anything of itself belongs, that very thing is its own cause (*αἴτιον*); and the universal is first, therefore the universal is the cause. ('Analyt. Post.,' i. 24.)

(49.) Universally, of all things it is impossible for there to be demonstration; for it would proceed indefinitely, so that thus there would be no demonstration at all. (‘Metaph.,’ iv. 4.) And it is not possible for the thought to go through the infinite. (‘Analyt. Post.,’ i. 22.)

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* See 'Categ.' c. 1, definition of *ὁμώνυμα* and *συνώνυμα*.

(50.) And those things are true and first which not through other things, but through themselves receive assent; for it is not necessary in scientific first principles for the “wherefore” to be inquired after, but each of the principles must itself of itself receive assent. (‘Top.,’ i. 1.) And in two ways it is necessary first to know: for as to some things it is necessary first to admit that they are; but as to others it is necessary to understand what the thing spoken of is; and as to others again both; for example, in the proposition that either to affirm or deny everything is true, we must assume the “is”; and in the triangle, that it signifies this particular thing; and in the monad both, both what it means and that it is. (‘Analyt. Post.,’ i. 1.)

(51.) But we assert that all science is not demonstrative, but that that of the immediate (ἄμεσα) is incapable of demonstration. And that this is a matter of necessity, is clear; for if it is necessary to understand the prior and those things from which the demonstration comes, and the immediate at any time enter into the demonstration, it is a matter of necessity that the immediate are not capable of demonstration. And this then we so affirm, and that there is not only science, but also some first principle (ἀρχή) of science by which we know the terms (ὅροι). It is necessary not only to know first the first things, either all or some, but also to know them more: for always that through which each thing is, is more (in a higher degree); for example, that through which we love, is more love. So that if we know by the first things and believe, those things also we know and believe more, since by them we know also the things which come after. (‘Analyt. Post.,’ i. 3. 2.)

(52.) And an immediate proposition (πρότασις ἄμεσος) is a beginning (ἀρχή) of demonstration, and an immediate proposition is that to which there is no prior proposition. (‘Analyt. Post.,’ i. 2.)

(53.) And of an immediate syllogistic beginning I call that the Thesis which need not be demonstrated, and which it is not necessary that he who is going to learn anything should possess; but what he who is going to learn anything must necessarily possess, is an axiom (ἀξίωμα). (‘Analyt. Post.,’ i. 2.)

(54.) The first things will be definitions (ὁρισμοι) incapable of demonstration. For definition is of what the thing is and of essence; but all demonstrations appear to go by hypothesis and to assume what a thing is; for example, mathematical demonstrations take for granted what a unit is and what odd is, and other kinds of demonstration in like manner.

The definition is a certain notification (γνωρισμός) of essence. (‘Analyt. Post.,’ ii. 3.)

(55.) He who defines shows either what a thing is or what the name means. (‘Analyt. Post.,’ ii. 7.)

All who in any way by a name give an account of a thing, manifestly do not give the definition of the thing, since every definition is speech (λόγος). (‘Top.,’ i. 3.)

What a triangle means, the geometer assumes; but that it is, he proves. (‘Analyt. Post.,’ ii. 7.)

(56.) And it is necessary to investigate, when considering things which are alike and do not differ, in the first place what they all have in common, then again with respect to other things what things they have which are of the same genus as the former, and are the same as one another in species, but different from the first named. And when in these things it has been found what they all have in common, and in the other things in like manner, we must consider again if there is anything in common in these things which have been taken, until you come to one notion (λόγος); for this will be a definition of the thing. But if a man does not come to one notion, but to two or more, it is manifest that what is sought cannot be one, but more than one. For example, if we should inquire what magnanimity is, we must consider in the case of some magnanimous persons whom we know, what one thing they all have by which they are such. For example, if Alcibiades is magnanimous, or Achilles, and Ajax, what one thing they have all in common? Non-endurance of insult; for the first made war, and the second was enraged, and the third killed himself.

Again in the case of others, such as Lysander or Socrates; if indifference in prosperity and adversity are the things that they have in common, these two things I take and consider what same things are contained in the absence of all feeling (ἀπαθεία) as to fortune, and non-endurance of insult. If they have nothing in common, there must be two species (εἴδη) of magnanimity. (‘Analyt. Post.,’ ii. 13.)

(57.) Of the things indeed which are in the definition, each will extend further, but all will not extend further. For of necessity there must be this essence (οὐσία) of the thing: for example, there is number in every Three (τριάς), odd (περιττόν), and the prime in both ways, both so as not to be measured by any number and not to be composed of numbers. This then is Three, number odd, and prime, and prime in this manner: for of each of these things some are in all odd numbers also, but the last is in Two also, but all are in none. (‘Analyt. Post.,’ ii. 13.)

(58.) And it is necessary, when a person is labouring at any whole thing, to divide the genus (γένος) into things indivisible in species, the first; for example, to divide number into Three and Two. (‘Analyt. Post.,’ ii. 13.)

All genus is divided by differences which are opposed to one another in division, as a living animal by the difference of quadruped and bird and fish. (‘Top.,’ vi. 6.)

That everything should fall under the division, if they be things opposed in which there is no middle, is not an assumption, for it is necessary that everything should be in one of them, if there shall be a difference (διαφορά) in it (the genus). (‘Analyt. Post.,’ ii. 13.)

It is requisite, moreover, to divide by privation (στέρησις), and those who cut into two parts divide by privation. And there is no difference in privation, so far as it is privation, for it is impossible that there should be species of a thing which does not exist; for example, of animals without feet or animals without wings, as there is in the case of winged animals and quadrupeds. (‘De Partib. Animal.,’ i. 3.)

(59.) Definition (ὁρίσμος) consists of genus and differences (διαφορῶν). (‘Top.,’ i. 8.)

It is requisite that he who defines well define through genus and differences, and these belong to those things which are plainly clearer than and prior to the species (εἶδος).

And there are three ways in which the definition is not from prior things. The first is, if through what is opposed that which is opposed is defined; for example, if through evil good is defined; for the opposed exist by nature. But to some the knowledge of each of them appears to be also the same, so that neither is one better known than the other. But it should not escape notice that some things perhaps it is not possible to define otherwise; for example, the double without the half, and all those things which of themselves are said in relation to anything (πρός τι): for in all such things to be is the same thing as to be related to something in some manner, so that it is impossible without the one to know the other; wherefore it is necessary in the notion (λόγος) of the one that the other also be included.

Another way is, if a man uses the very thing which is defined. But this escapes notice when he has not used the name itself of the thing defined: for example, if he defined the sun to be a star which appears in the day-time; for he who employs the word day employs the word sun. And it is requisite, in order that such errors may be detected, to exchange the name (ὄνομα) for the notion (full speech, λόγος): for example, that day is the passage of the sun above the earth; for it is manifest that he who has spoken of the passage of the sun above the earth has spoken of the sun. So that he who has employed the word day has employed the word sun. A third way is, if that which is opposed in division is defined by that which is opposed in division; for example, that odd is greater than even by a unit. For things of the same genus opposed in division exist by nature, and odd and even are opposed in division; for both are differences of number. (‘Top.,’ vi. 4.)

(60.) To know what a thing is, is the same as to know why it is. What is an eclipse? Privation of light from the moon through the earth intercepting (the light). What causes an eclipse? or why is the moon eclipsed? Because the light fails, owing to the interposition of the earth. What is symphony? A proportion (λόγος) of numbers in sounds high or deep (ὀξύ, βαρύ). Why is the high symphonious with the deep? Because the high and deep sounds have a proportion (λόγος) of numbers. (‘Analyt. Post.,’ ii. 2.)

(61.) We seek the cause after we know that a thing is; but sometimes they are manifest at the same time also; but it is not possible to know the cause before we know that the thing exists. (‘Analyt. Post.,’ ii. 8.) For it is impossible to know what a thing is when we are in ignorance whether it exists or not.

And both the notion or expression (λόγος) appears to give evidence to phænomena, and phænomena to the notion. (‘De Coel.,’ i. 3.)

(62.) The cause is the middle (μέσον), and in all things this is sought. (‘Analyt. Post.,’ ii. 2.)

(63.) Not only that a thing “is” ought the definition (ὁριστικός λόγος) to show, as the most part of definitions declare, but the cause also ought to be in it, and to be clear. But the notions of the definitions are as conclusions: for example, what is quadrature? It is a rectangular equilateral figure being equal to a figure of unequal sides.* And such a definition is an expression of the conclusion. But the definition which says that quadrature is invention of a middle, states the cause of the thing. (‘De Animal.,’ ii. 2, § 1.)

(64.) And it appears that not only what a thing is, is useful towards knowing the causes of the accidents of essences (τῶν συμβεβηκότων ταῖς οὐσίαις), as in mathematics what a straight line is and what a curved line is, or what a line and a plane are, is useful towards seeing how many right angles the angles of a triangle are equal to; but conversely also the accidents help in a great degree to perceiving what the thing is; for when we are able by the appearance (φαντασία) to give an account of the accidents either of all or of the greater part, then concerning the essence also we shall be able best to speak; for of all demonstration what a thing is (τὸ τί ἐστιν), is the beginning. So that in all definitions in which it does not happen that we can recognise the accidents, and cannot even form a conjecture of them easily, it is manifest that they are all enunciated dialectically (διαλεκτικῶς) and emptily (κενῶς). (‘De Animal.,’ i. 1, § 8.)

(65.) And of some things some other thing is the cause, and of other things not.

Accordingly it is manifest that of those also which belong to the class of what a thing “is,” some are immediate (ἄμεσα) and first principles (ἀρχαί), which we must assume (ὑποθέσθαι) both to be, and we must assume what they are, or in some other way make clear, which the arithmetician does; for both what unity is and that it is he assumes. But as to those things which have a middle (μέσον), and of which something else is the cause of the essence, we can, as we have said, show by demonstration. ('Analyt. Post.,' ii. 9.)

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* This is what the 14th Proposition of the Second Book of Euclid shows.

(66.) And of proposition (putting, placing, θέσις) that which takes for granted either of the parts of the enunciation, for example, that a thing is, or is not, is Hypothesis (ὑπόθεσις): but the proposition without this is Definition; for the definition is proposition (θέσις); for the arithmetician lays down (puts, places, τίθεται) that the unit is indivisible, as far as quantity is concerned: but it is not hypothesis; for what a unit is and that there is a unit is not the same thing. ('Analyt. Post.,' i. 2.)

(67.) All demonstrative science is about three things, two of which are assumed to be; and these two are genus, the affections (παθήματα) of which by themselves it contemplates, and what are called common axioms (ἀξιώματα) from which first principles science demonstrates; and thirdly, the affections (πάθη) of which what each means it takes for granted. ('Analyt. Post.' i. 10.)

(68.) It is clear that it is not possible to demonstrate the peculiar first principles of each thing: for those first principles will be the first principles of all things, and knowledge of those is that which is supreme over all. For he knows more who knows from the higher causes: for he knows from the prior when he knows from causes which depend not on other causes. So that if he knows more and most, that science also will be both more and most. ('Analyt. Post.' i. 9.)

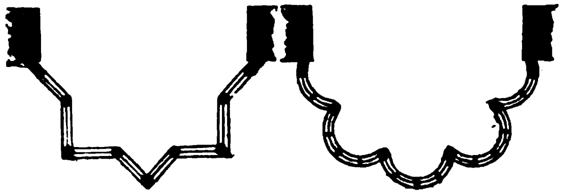
(69.) Accordingly that it is impossible to have science from demonstration, if a man does not know the first principles which admit of no middle (ἀρχαί αἱ ἄμεσαι), has been said before. But as to the knowledge of things which want a middle, a man may be in doubt. All animals have an innate discerning faculty, which men call perception (αἴσθησις). And as they have perception, in some animals there is a permanence (μονή) of the thing perceived (αἴσθημα); and in others there is not. In those animals, then, in which it is not, there is either wholly, or with respect to things of which there is no permanence in them, no knowledge except of what they perceive: but in those animals in which there is, there is the faculty of having the perception in the mind, though they do not then perceive. And many animals being such, there results a difference among them, so that some have reason owing to the permanence of such things, and some have not. Accordingly from perception comes memory (μνήμη), as we call it, and from the frequent remembrance of the same thing comes experience (ἐμπειρία): for many remembrances in number are one experience. And from experience, or from a whole thing remaining tranquil in the mind as one thing apart from the many, whatever thing in all these things is as one and the same thing, is the beginning of art and of science; if about production (γένεσις), of art; if about that which is or being (τὸ ὄν), of science. Neither indeed do the faculties (ἕξεις) exist in the mind separate, nor do they proceed from other faculties which are more intelligent, but they proceed from perception; as in battle when a flight has taken place, when one stops, another stops, and then another, until order is restored: and the mind exists in such a manner as to have the faculty of being so affected. For when one thing of things which are not different stands, it first of all is in the mind as universal (for the mind perceives the individual, but the perception belongs to the universal, for example, it belongs to mankind, but not to a man ('Callias')): and again it abides in these until the undivided and the universal have abided: for example, such or such an animal abides, until animal generally abides; and in this in like manner. It is manifest then that it is necessary for us to know the first things by induction: for perception also in this manner produces the universal in the mind.

And since of the faculties that concern the understanding (διάνοια), by which we learn the truth, some are always true, and some admit of falsehood, as opinion and reasoning (λόγισμος); and since science and intellect (ἐπιστήμη καὶ νοῦς) are always true, and there is no other kind of science more exact than intellect, and since the first principles are clearer than the demonstrations, and since all science is together with reason (λόγος),* there can be no science of the first principles: and since nothing can be truer than science except intellect, intellect must be intellect of first principles: and this appears both from considering these things, and that the beginning of demonstration is not demonstration, so that neither is science the beginning of science. If then we have no kind of truth which exists independent of science, intellect (νοῦς) must be the beginning of science. ('Analyt. Post.' ii. 19.)

ORICHALCUM or AURICHALCUM. [Brass.]

ORIEL. The origin of this term is uncertain; its use is, however, thoroughly established, and the meaning now affixed to it is sufficiently clear and precise. It is applied to that particular kind of bay-window which is made to project from the upper story of a building. The distinction therefore between a bay and an oriel is this: by a *Bay* is understood a projecting window, or rather a projection pierced with window openings in its entire width, and rising immediately from the ground, whether it be confined to the lower part of the building or carried up through one or more stories above the ground floor; by an *Oriel*, is understood a bay which does not descend to the ground, but is suspended over the face of the wall beneath it. Oriel accordingly corresponds with the German terms *Erker-fenster* and *Chor-fenster*, which are almost the only ones of similar import in any foreign language. This absence of a name for it is accounted for by the thing itself being little known in the architecture of other countries, and in our own it occurs only in our Domestic Tudor, such form of window being very rare indeed in ecclesiastical structures. In our domestic, which also comprises collegiate, architecture, it is a beautiful and valuable feature, and one which admits of very great diversity of design, and imparts much variety and liveliness of effect to a building, more especially if there be ground-bays likewise, the two kinds of projection both harmonising and contrasting with each other. The colleges of Oxford and Cambridge afford numerous excellent examples of both bays and oriels.

Internally there is no distinction between bays and oriels, inasmuch as both the one and the other form a recess whose sides are filled with windows. But greater variety of plan occurs in oriels than in bays, which are usually more spacious as to breadth, and of shallower proportions as to depth; they are also either rectangular in plan, or form three sides of an octagon, whether a regular one or not; whereas curved forms are of frequent occurrence in the plans of oriels, and are occasionally combined with straight ones. Yet as similar plans do occur in bays, no real distinction can be founded upon such accidents of design. Thornbury Castle, Gloucestershire, contains an example of a bay of very unusual character, both in respect to plan and elevation, its plan in the upper part being different from that of the lower, and in some degree projecting over it, as is indicated in the annexed figures, the first of which describes the plan of the lower, the other of the upper floor.



Bays generally terminate in either a plain or embattled parapet; but oriels are for the most part made to show some sort of roof, either rising behind or resting upon the mouldings which serve as their cornice. Occasionally this roof or *crown* is rendered an ornamental part of the design, and terminated by some kind of finish. Oriels may therefore be described as consisting of three distinct parts, namely, the supporting portion, consisting of a series of mouldings, splayed off so as to come down to a point below, somewhat after the manner of a corbel (for which member we would accordingly suggest *corbel-stool* or *corbel-base* as a significant and very convenient term); 2ndly, the body of the oriel, consisting of the *window-apron* or window-parapet, and the window-openings themselves, the former of which is almost invariably panelled so as to correspond with the lights, whereby the whole is made to consist of a series of panels, those in the lower range being blank or solid, the others perforated and glazed; 3rdly, the *crown* or roofing, occasionally including under that term the ornamental finish, of whatever kind it may be, above the windows, when that happens to form a conspicuous termination to the design, as is the case with the semicircular oriel at Great Chalfield, where the parapet is formed by a rich bandeau or crown of strawberry-leaf ornaments or *Tudor-flowers* with open work between them.

ORIFLAMME. [Banner.]

ORILLON, is the term applied in fortification to the projecting tower placed at the shoulder angle of the bastion. [See M in the plate to Bastion.] This orillon covers the flank from view from the front; it is frequently found in old fortresses and also in Coehorn's system of fortification.

ORI'ON (Constellation). We have already noted the appearance which the Greek astro-mythological system has of being an application of existing fables to a subdivision of the stars derived from the East, mixed perhaps with the Oriental allegories, imperfectly understood. The trivial character of the myths by which the Great Bear and Orion, perhaps the two most remarkable constellations in the heavens, are accompanied, is enough of itself to upset any claim to high antiquity for the system above noted. We owe this brilliant cluster, according to Hyginus (of whose two or three very slight stories this is the most striking), to the fraternal solicitude of Apollo that his sister Diana should remain unmarried, or at least that she should not marry one Orion, a son of Neptune according to some, or of a rather curious parentage according to others. The deity above mentioned, when persuasion had failed, hit upon a method of preventing his sister's match, as follows. He asserted that she could not hit a black object which appeared in the sea at a distance; and she, being a good markswoman, showed him immediately that she could. This black object, however, was the head of her lover, who was swimming at the time, and the end of it was, that, according to custom, he was immediately gazetted as a constellation, with his club and lion's skin.

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* The word λόγος is rendered 'ratio' by the Latin translation. Trendelenburg translates the passage thus:—"jede wissenschaft aber mit einem grunde verknüpft ist." Perhaps λόγος may be understood as in No. 2. Λογισμὸς should be related to λόγος as ὁρισμος (defining, terming) is to ὅρος (finis, term).

Orion is surrounded by Eridanus, Canis Major, Gemini, Auriga, and Taurus. The position of his belt, with respect to Aldebaran, and Sirius, and the proximity of Procyon, Castor and Pollux, the Pleiades, &c., render it difficult to forget and unnecessary to describe this part of the heavens. The list of stars is as follows: α and β, of the first magnitude, were frequently called Betelguese or Betelgeux, and Rigel corruptions from Arabic names; γ was called Bellatrix.

Character.	No. in Catalogue of Flamsteed, (Bradley).	No. in Catalogue of British Association.	Magnitude.
π^1 *	1	1486	4
π^2	2	1491	4
π^3	3	1495	4
β	19	1623	1
γ	24	1687	2
η	28	1684	3
δ	34	1730	2
λ	39	1749	4
ι	44	1762	4
ϵ	46	1765	2
σ	48	1780	4
ζ	50	1794	2
κ	53	1843	3
α	58	1883	1
μ	61	1928	4
	(729)		4

ORMUZD. [ARIMANES.]

OROGRAPHY, or OROLOGY, from ὄρος a mountain, and γραφή description, and λόγος, discourse, respectively, (*the science of mountains*,) belongs technically to three branches of natural knowledge, physical geography, meteorology, and geology; but it is usually regarded as a part of the first, and confined to the subjects of the configuration, magnitude, and distribution of mountains, with some general reference, also, to their climate, and to their relations to organic nature.

Though the term mountain be universally understood, yet it will be found very difficult to define strictly what is meant by it. From the mole-hill in the meadow, to the gigantic Himalayas, the gradations are infinite, and no positive line can be drawn between the hill and the mountain. Moreover, the name is sometimes given to a single elevation or peak, as Mount Ætna, &c., and sometimes to a whole and extensive cluster of eminences, as Mount Caucasus. Isolated mountains are rare, and when they do exist are generally, though not always, volcanic.

The general disposition of mountains is in groups or chains. The word group explains itself, but what is understood by a chain may not be so clear. When hills or mountains are so arranged as to form a line or band whose length greatly exceeds its breadth, such a disposition, whether the line be straight or curved, is called a chain, and sometimes a ridge; though the latter name is more exclusively applied to the lesser chains. We are not however to understand by a chain of mountains, a single unbroken longitudinal eminence, like that formed by the connected roofs of a row of houses. A chain of mountains, on the contrary, is very irregular, and composed of many subordinate parts. In what is regarded by some geographers as a complete chain there are three parallel or nearly parallel ridges; the centre one is usually the highest. These three ridges, though distinct, are seldom equidistant from each other, and they are frequently united. From the points of junction, and from different parts of the outer ridges, other chains strike off at various angles, and these in turn send off other ramifications, which go on dividing and diminishing in height till the last undulations are lost in the general surface of the plain. These different branches of a chain have received various and very arbitrary names. Some divide the whole system of a chain into the primary, principal, primordial, or great chain, and secondary and tertiary chains; but these names having now reference to the order of formation of rocks rather than to their disposition, though the latter circumstance is greatly dependent on the former, they are at present confined to geological considerations, and we therefore say such a chain or ridge is a branch of some other chain or ridge. Thus the Apennines are a branch of the Alps. Minor ramifications, when short, are called spurs. Wherever the main chain sends off other chains, the former is, at that particular spot, higher than elsewhere, so that between two consecutive elevations there is an apparent depression: hence the summit or ridge-line of the main chain is divided into heights, which are called peaks, domes, &c., according to their shape; and depressions, which receive the general name of passes, because they are the places where the passage over the chain from opposite valleys is most easily effected. These passages or passes are termed *cols* in the Alps, *ports* in the Pyrenees, and *pertuis* in the Jura. They are also called gorges or defiles, but incorrectly, for the gorge is properly the contracted part of a valley, and the defile, a very narrow passage at the foot of the mountains or winding amongst them. The ridge-line of great chains is also irregular in breadth as well as height: it is sometimes very narrow and sometimes very broad, and in some places spreads out into what is termed table-land (Langfield in Norway). Table-lands, or plateaus, are however not always of this terrace form: they are not unfrequently sunk, if we may so say, into the broad summit of the ridge, so as to be surrounded by lofty eminences and peaks. Table-land is also sometimes ascended by gentle acclivities without any appearance of mountains.

The valleys which are situated between the parallel ridges of the main chain are termed longitudinal valleys; their axis, and consequently the principal watercourse, is nearly parallel to the direction of the chain. The valley of the Rhône above the lake of Geneva, the valley of the Magdalena in South America, &c., may be taken as examples. Two things have been remarked in longitudinal valleys; first, that there is sometimes so perfect a conformity between the re-entering angles on one side and the salient angles on the other, that if it were possible to bring the two sides into contact, they would perfectly correspond, so as to leave no trace of their having been separated; and, secondly, it has been observed, that the side of the valley opposite to the centre ridge is the steepest. These observations are true as regards many places, but are by no means to be received as universally correct. The other valleys, whose axes form various angles with the direction of the great chain, are the principal valleys of a country, and are usually designated by the names of the chief rivers which flow through them. The valleys of the tributary streams which empty themselves into the main rivers are called lateral valleys. The terms upper and lower valley are sometimes used to denote the parts of a valley as they lie along the higher or lower part of a river's course. Such then are the parts of a regular chain of mountains, but we are not to suppose that all those great elevations to which we give the name of chain are thus regularly formed. Mountains are sometimes grouped, as we have said, so as to present no appearance of a chain; sometimes the chains run parallel, but wholly independent of each other; in some cases they radiate from a common centre or nucleus. Indeed nothing can be well more irregular than the arrangement of mountains, and they differ as much in height, steepness, and particular appearance. By some (Bergmann) it has been imagined that in chains running north and south the western slope is the most abrupt, and that when the chain runs east and west the southern slope is the steepest. But this is far from being always the case, and General Andreossy has laid down as a principle that the steep side of a chain of mountains is that which looks towards the higher part of the general slope on which the chain is set. This opinion is doubtless better founded than that of Bergmann, nevertheless it is not strictly correct; and there seems reason to believe that no general law obtains on this subject.

The appearance presented by chains of mountains is not only very different in different parts, but the very same mountains when seen at a distance no way resemble their aspect when seen nearer. At a distance the minute irregularities are lost in the general contour, and the particular shadows are blended into a uniform tint. The forms of rocks generally depend on their nature, and a practised eye can sometimes pretty correctly divine the latter from the former. These may either present the aspect of needles or sharp pointed masses, or the summits may be dome-shaped, or stretch along like a vertical wall, either entire or bearing a resemblance to ruined battlements and towers; sometimes the whole mass is piled up into a succession of gigantic steps or terraces. Individual mountains and hills also vary in form; those which are volcanic are generally conical; others are round, oval, lumpy, saddle-backed, &c.

Mountain-chains are the natural water-sheds (the *divortia aquarum*), but it must not be thence inferred, as has too frequently been the case, that all water-sheds are mountain-chains. This erroneous idea has covered our older maps with mountains where in nature not a hill is to be seen.

Another error is to regard the mountains of the earth as so many connected chains, which, by starting from some particular point, may be traced stretching and branching continuously over the whole surface of the globe. The fallacy of such pretended continuity is evident from the difference in the arrangement as described by different writers. The truth is, that mountains are scattered over the surface of the land in the greatest confusion, here isolated, there in groups or in chains; the chains being in some places single and independent, in others connected; in one place running in parallel directions, in another intersecting, crossing, or branching off at different angles; in some cases completely enclosing a certain extent of country so as to form an entire and perfect basin, in others only partially enclosing a space. In one country the mountains are set in the centre, or near one of its coasts, and in the direction of the greatest length of the country; in another, they are set across the country. In fact, the chains are observed to be in all possible directions, both as regards the points of the compass and the trending of the coast-lines. Thus with the exception of the Andes and the Rocky Mountains, the Appalachians, the Ghauts of India, the coast-mountains of Abyssinia, the Scandinavian Alps, and the Apennines, there is very little conformity between the direction of mountain-chains and the configuration of countries.

Mountains have a very important part to perform n the general economy of the earth; they arrest the fleeting clouds, whose precipitated waters they store up in their interior and exhaustless reservoirs, whence springs are continually issuing, which unite and form those streams that fertilise the plains, or, collected into mighty rivers, favour the transport of commodities and facilitate the intercourse between the ocean and the interior of the continents. The influence of mountains on local climate is all-powerful, and depends upon the direction in which they lie as regards the sun's course, their height, their position on the surface of the globe, their proximity to or remoteness from the sea, the winds they arrest or give passage to, &c. Mountains have moreover a climate of their own, or rather a great variety of climates. Thus, in ascending from the sea towards the summit of the Andes, almost every kind of climate is passed through, nearly as completely as if the traveller were to proceed from the equator towards the pole. At an elevation of about 16,000 feet on the Andes under the equator, we reach the lower limit of perpetual congelation; and mountains in that region which exceed that height have their summits covered with eternal snow. The line of perpetual congelation is, however, far from being parallel with the general surface of the earth. It approaches that surface as it advances towards the poles, but the laws which determine this line are still imperfectly known. [Climate; Snow, Perennial.]

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* π^1, π^2, π^3, of Bayer are g, π^1, and r in modern catalogues.

The limits of perpetual congelation, as ascertained from the stability of snow on the mountains, are subject to vary with the particular aspect of the mountains and other local circumstances. Thus, generally speaking, the snow-line is highest on the south side of mountains in the northern hemisphere, and *vice versâ*; but this is not always the case; and the line of perpetual snow is much higher on the northern than on the southern side of the Himalaya mountains. Mr. Pentland states that the limit of perpetual snow is at an elevation of 15,800 feet on the mountains of Vilcanota in South America, which are as far south as 14° 33′.

The fact of the cold increasing as we ascend mountains is due in part to the greater rarity of the atmosphere in the higher regions, and to their greater distance from the radiated heat of the plains; nevertheless the particular aspect of various parts of mountains as regards the sun, and the conformation of the higher valleys, greatly modify the cold of particular places; and a much greater heat is sometimes experienced in a high valley than is felt in one much lower down. To this circumstance is due in part the seeming anomalies that are met with in the habitation of plants, many being found at heights where they would be little expected.

Though mountains are such striking objects, and, when contemplated only with respect to their absolute elevation above the sea, appear to be enormous protuberances on the earth's surface, they are very inconsiderable when compared with the whole mass of the globe. The habitable parts of the earth, at least those where population is most dense, and in which human industry is most concentrated, all lie within a few hundred feet above the sea, which may be regarded as a part of the true surface of the sphere. But even the height of the loftiest mountains, which is about five miles, is only about one eight-hundredth part of the radius of the earth. In books of travels we often find the distance mentioned at which a particular mountain is visible. As assertions of this kind are sometimes loosely made, the following rule will serve for roughly estimating the distance at which a mountain of known height can be seen from the surface of the sphere: multiply the square root of the height of the mountain in feet by 1·2247; the product will be the distance in miles at which the mountain is visible.

With regard to the heights of mountains it may be observed that they vary considerably. Some authors, however, regard every eminence below 1000 feet as a hill. Since the application of the barometer to the admeasurement of heights, there are few mountains of any importance, in Europe at least, whose elevation above the sea is not now known and registered. A list of the principal mountain heights on the globe would fill a volume. It may be sufficient here to give the heights of the principal peaks of some of the more important chains.

Europe.—Mont Blanc, highest point of the Alps, and of Europe, 15,744 feet; Mont Perdu, Pyrenees, 10,994; Monte Corno, Apennines, 9523; Lomnitz, Carpathians, 8799; Sneehetta, Dovrefield, Norway, 8122; Mulhacen, Sierra Nevada, Spain, 11,483; Puy de Sanci, Auvergne, France, 6200; Mont Mezin, Cevennes, France, 5795; Ætna, Sicily, 10,870; Olympus, Greece, 9754; Vesuvius, 3947.

British Islands.—The greater number of the heights about to be stated, are derived from a table of the 'Altitudes above the mean level of the sea of the stations composing the principal Triangulation' of the Ordnance Trigonometrical Survey of Great Britain and Ireland, given in the account of that triangulation recently produced by Captain A. R. Clarke, R.E., under the direction of Colonel Sir Henry James, R.E., F.R.S., Superintendent of the Survey, London, 1858. The altitudes of a few stations but little elevated above the sea, are included for comparison. Fractions of a foot are either omitted, or reckoned as an entire foot, except in heights below 1000 feet, in which they are given.

England.—Sca Fell, highest point in England, 3229; Helvellyn, 3055; Skiddaw, 3038; Cross Fell, 2928; Cheviot, 2669; Coniston Fell, 2575; Ingleborough, 2373; Great Whernside, 2310; Malvern, 1396; Mendip, 979·2; Inkpen Beacon, the loftiest summit of the chalk formation, 972·8; Leith Hill, 967; Fairlight Down, 583·7; Beachy Head, 532·4; Lundy Island, 466; St. Paul's Cathedral, top of cross, 417·9; Severndroog Castle, Shooter's Hill, ground, 406·4; Epping Poorhouse, 371·2; Greenwich Observatory, vane, 214; Ordnance Map Office, Southampton, 78; York Minster, ground, 53; Ely Minster, ground, 51·6; Norwich Cathedral spire, ground, 19·7.

Wales.—Snowdon, highest point in the principality, 3590; Carn Llewellen, 3471; Cader Idris, 2959; Great Orme's Head, 683·1.

Scotland.—Ben Nevis, highest point in the British Isles, 4406; Ben Macdui, 4296; Ben Lawers, 3984; Ben Lomond, 3192; Schehallien, 3564; Ben More, Mull, 3185; Ben More, South Uist, 2034.

Ireland.—Carran Tual, Kerry, highest point in Ireland (?), 3412, doubtful; Slieve Donard, 2788; Nephin, 2638; Mourne Mountains, 2493, doubtful; Howth, 555.

Asia.—Mount Everest, Nepaul, 29,002 (highest mountain known, measured by Colonel Waugh); Kunchin-junga, Sikkim, W. part, 28,178, E. peak, 27,826; Dhawalagiri, Nepaul, 26,862; Juwahir, 25,670. These are peaks of the Himalaya. Ophir, Sumatra, 13,840; Mowna Roa, Sandwich Islands, 13,760; Egmont, New Zealand, 8840; Italitskoï, Altaian chain, 10,735; Ararat, Armenia, 17,212; Arjish, Anatolia, 10,000?; Olympus, Anatolia, 6500; Lebanon, Palestine, 9517; Awatska, a volcano in Kamtchatka, 12,000 feet.

Africa.—Kilimandjaro, lat. 4°·0′ S. in the true Mountains of the Moon, 20,000?; Abba Jarat, Abyssinia, 15,008; Geesh, in Abyssinia, 15,000?; Peak of Teyde, Teneriffe, a volcano, 12,205; highest peak of Atlas chain, 12,000, and perhaps more; Table Mountain, 3816.

America.—Sorate or Illampu, (highest point in America) 25,200; Illimani (the richest gold mountain of Peru), 24,200; Chimboraço, Andes, 21,424; Antisana, 19,136; Cotopaxi, 18,775; Pichincha, 15,931; Popocatepetl, Mexico, 17,720: the last four are volcanoes. Mount St. Elias, U.S., 17,850; Fremont's Peak, Rocky Mountains, 13,570; Mount Washington, Appalachians, 6428.

Mount Terror, 13,384; Mount Erebus, 12,367; both in the antarctic lands.

The particular history of important ranges of mountains, as Alps, Altai, &c., will be found in Geog. Div. under their names, respectively, or under those of the countries to which they belong.

OROSELONE. [Athamantin.]

O'RPHICA, certain works falsely ascribed to Orpheus, which embodied the opinions of a class of persons whom Müller thus describes: "These were the followers of Orpheus (*οἱ Ὀρφικοί*); that is to say, associations of persons who, under the guidance of the ancient mystical poet Orpheus, dedicated themselves to the worship of Bacchus, in which they hoped to find satisfaction for an ardent longing after the soothing and elevating influences of religion. The Dionysus, to whose worship these Orphic and Bacchic rites (*τὰ Ὀρφικὰ καλεόμενα καὶ Βακχικά*, Herod., ii. 81) were annexed, was the Chthonian deity Dionysus Zagreus, closely connected with Demeter and Cora, who was the personified expression, not only of the most rapturous pleasure, but also of a deep sorrow for the miseries of human life. The Orphic legends and poems related in great part to this Dionysus, who was combined, as an infernal deity, with Hades (a doctrine given by the philosopher Heraclitus as the opinion of a particular sect); and upon whom the Orphic theologers founded their hopes of the purification and ultimate immortality of the soul. But their mode of celebrating this worship was very different from the popular rites of Bacchus. The Orphic worshippers of Bacchus did not indulge in unrestrained pleasure and frantic enthusiasm, but rather aimed at an ascetic purity of life and manners. The followers of Orpheus, when they had tasted the mystic sacrificial feast of raw flesh torn from the ox of Dionysus (*ὠμοφαγία*), partook of no other animal food. They wore white linen garments, like Oriental and Egyptian priests, from whom, as Herodotus remarks, much may have been borrowed in the ritual of the Orphic worship." ('History of the Literature of Greece,' where the reader will find a full account of the Orphic theology.)

Of the Orphic writers the most celebrated are Onomacritus, who lived under Pisistratus and his sons, and Cercops, a Pythagorean, who lived about B.C. 504. Works ascribed to Orpheus were extant at a very early period. Plato mentions several kinds of Orphic poems; but he intimates that they were not genuine. Aristotle speaks of them as the *so-called* Orphic poems (*τὰ καλούμενα*). In later times all manner of works on mysteries and religion were ascribed to Orpheus. There are also Orphic poems later than the Christian era, which are difficult to be distinguished from those of earlier times. In Fabricius's 'Bibliotheca Græca,' there is a list of the writings ascribed to Orpheus. [Orpheus, in Biog. Div.]

ORPIMENT. [Arsenic.]

ORRERY. There are four planetary machines to which distinct names have been given, corresponding to the phenomena they are intended to exhibit, and which, when combined so as to derive their motions from a common origin, constitute what is now generally understood by an orrery. These machines are the *Planetarium*, the *Tellurian*, the *Lunarian*, and the *Satellite machine*. The planetarium is a mechanical representation of the orbital motions of the planets about the sun, either in circles or ellipses, and with angular velocities either uniform or variable, according to the quality of the instrument. The tellurian and lunarian, when connected in their improved form, exhibit the motion of the moon about the earth and that of the earth about the sun, and the principal phenomena which accompany the changes in their relative positions, such as the succession of day and night and the variable length of both according to the season of the year, the eclipses of the sun and moon, the variations in the moon's latitude, velocity, and distance from the earth, the progressive motion of her apogee, and the retrogradation of her nodes, &c. The satellite machine is chiefly intended to represent the motions of Jupiter's satellites about their primary, combined with the motions of the latter about the sun.

The origin of the term "orrery" is thus given by Mr. Desaguliers, in his 'Course of Experimental Philosophy,' 4to, London, 1734, i., p. 431. After stating his belief that Mr. George Graham, about the year 1700, first invented a movement for exhibiting the motion of the earth about the sun at the same time that the moon revolved round the earth, he remarks, "This machine being in the hands of an instrument-maker to be sent with some of his own instruments to Prince Eugene, he copied it, and made the first for the late Earl of Orrery, and then several others with additions of his own. Sir Richard Steele, who knew nothing of Mr. Graham's machine, in one of his lucubrations, thinking to do justice to the first encourager, as well as to the inventor, of such a curious instrument, called it an *orrery*, and gave Mr. J. Rowley the praise due to Mr. Graham."

In the latter part of the 17th century Huyghens and Roemer employed themselves in the construction of planetary machines in conformity with the Copernican doctrine. The one invented by Huyghens, who first introduced a systematic method of calculating with precision the necessary wheel-work for these machines, received from its author the name of *the Automaton*. It derived its motion from a spring regulated by a balance, the pendulum not having been then introduced as a regulating agent, and served for many years as a pattern in the construction of orreries, as did the instrument of Roemer, called by him a *Planetarium*, in the construction of machines intended chiefly to exhibit the orbital motions of the planets. Roemer had also invented a *satellite machine* prior to the year 1679, the original or a copy of which was presented by him in that year to the English astronomer Flamsteed. Both his machines are described in his 'Basis Astronomiæ,' printed in 1735. We may also mention the *Planetarium* of the Royal Institution of London, constructed about the year 1801, on a plan suggested by Dr. Young and the Rev. W. Pearson, and described in the paper 'On Planetary Machines,' in the 'Edinburgh Encyclopædia,' by the latter gentleman.

The chief part of every orrery is the mechanism composing the planetarium, by means of which the paths of the planets about the sun and their relative periodic times are exhibited with more or less approach to truth: and this mechanism, with the method of computing it, being once understood, it will be easy to extend the same principles to the more complex cases in which the satellites revolve about their primaries at the same time that the latter rotate upon their axes and revolve about the sun, as well as to those in which the parallelism of the planets' axes and the changes in the positions of their orbits, &c. are sought to be represented. For this reason we shall confine ourselves to the method of computing the wheel-work, which will give the relative periods with any required degree of accuracy, and to the explanation of a very ingenious contrivance by means of which a true elliptic orbit may be produced. Before, however, proceeding to this, we would caution the purchasers of these expensive toys (those exhibited in the shops of mathematical instrument-makers vary in price from sixteen to forty guineas) against a defect which was at one time not uncommon and may still exist, and which, while it rendered them worse than useless, showed how little knowledge their contrivers could have possessed of the science they are intended to illustrate. We allude to the substitution of the synodic for the sidereal periods, whereby each planetary ball was made to revolve about the sun in the time which ought to have elapsed between two consecutive conjunctions of such planet with the earth.

To produce the revolution of the planetary balls about the sun, a system of vertical concentric tubes is usually employed, which are adjusted very near to each other, but yet so far removed as not to influence each other's motion. These tubes are of different lengths, the innermost being the longest, and to the superior extremity of each a radius vector is attached, and thereby made to revolve once during each revolution of the tube. The lower extremities of the tubes form the arbors or axes of as many toothed-wheels, which are either immediately driven by pinions adjusted to a vertical axle called the 'annual arbor,' or derive their motions indirectly from those pinions by means of an interposed train of wheels. The determination of the relative number of teeth which must be given to the wheels and pinions in order to produce any required motion may be thus explained.

A pinion generally means a wheel consisting of a less number of teeth than that which it drives, but in the present article this restriction is unnecessary. The teeth of a pinion are called *leaves*. The number of revolutions made by the wheel during one revolution of the pinion by which it is driven, is found by dividing the number of leaves in the pinion by the number of teeth in the wheel:—thus, if there be 35 leaves and 7 teeth, the wheel will make $\frac{35}{7}$ or 5 revolutions during one revolution of the pinion; but if there be 7 leaves and 35 teeth, the wheel will make $\frac{7}{35}$ or $\frac{1}{5}$ of a revolution during one entire revolution of the pinion. If to the axle of the wheel be adjusted a second pinion, which drives a second wheel, and if to the axle of this wheel a third pinion be adjusted which drives a third wheel, and so on, then the number of revolutions made by the last wheel during one revolution of the first pinion will be found by multiplying together the number of leaves in the several pinions, and dividing the result by the product of the number of teeth in the several wheels:—thus if there be four pinions, having 7, 8, 9, and 10 leaves respectively, and the same number of wheels, having 20, 21, 22, and 23 teeth respectively, the number of revolutions made by the last wheel during one revolution of the first pinion will be $\frac{7 \times 8 \times 9 \times 10}{20 \times 21 \times 22 \times 23} = \frac{6}{253}$, or, in other words, the last wheel will revolve six times during 253 revolutions of the first pinion. Conversely the ratio which the product of the number of leaves must bear to the product of the number of teeth, in order to produce any required relative motion between the first pinion and the last wheel, is found by dividing the number of revolutions made by the wheel by the number of revolutions to be made in the same time by the pinion. The actual number of teeth to be given to the wheels and pinions, as well as the number of wheels and pinions to be employed in any particular case, is matter of convenience, not of necessity: in every instance the employment of a single pinion and a single wheel is theoretically sufficient, but in practice it is generally desirable to avoid the use of wheels or pinions with a very large or very small number of teeth. In the planetarium of the Royal Institution the number of teeth is in no instance under 7, or above 137. In a more complete instrument, constructed by Dr. Pearson in 1813, the limits were 14 and 241. The same gentleman recommends about 10 teeth to the inch, which he considers "sufficiently strong, and not liable to unnecessary shake, when the teeth and spaces are made equal and at a proper depth for action." The lowest number employed by him was 7 to the inch, the highest 13.

Supposing we wish the radius which carries the ball representing the earth to revolve once during each revolution of the annual arbor, it is only necessary that the wheel which is adjusted to the lower extremity of the earth's tube should contain the same number of teeth as the pinion by which it is driven, and which is adjusted to the annual arbor. In this case each revolution of the annual arbor will be the measure of one solar year. If each revolution of the annual arbor be required to represent any assigned portion of a year, the necessary modification in the relative number of teeth in the earth's wheel and pinion will appear sufficiently obvious from what has preceded; but for the sake of simplicity, we shall assume that the earth's radius vector revolves exactly once during each revolution of the annual arbor, and upon this supposition we have now to fix the relative number of teeth which should be given to the wheels and pinions which regulate the motions of the other planetary balls. It generally happens that the number of revolutions which the radius vector of any one of the planetary balls is required to make during one revolution of the annual arbor is expressed in the form of a decimal. Suppose, for instance, that the relative motion required were that of the earth and Jupiter. Jupiter revolves in 4332·5848 mean solar days; the earth in 365·2564 mean solar days; the number of revolutions made by Jupiter during one revolution of the earth is therefore $\frac{365·2564}{4332·5848} = ·0843045$. If this decimal be converted into a continued fraction, the resulting series of fractions, which approximate more and more nearly to ·0843045, will be found to be $\frac{1}{11}, \frac{1}{12}, \frac{7}{83}, \frac{29}{344}, \frac{94}{1115}$, &c., any one of which, according to the degree of accuracy required, may be taken for the ratio which the number of leaves in the pinion must bear to the number of teeth in the wheel, if only a single wheel and pinion be employed, or the ratio which the product of the number of leaves must bear to the product of the number of teeth, if a train of wheels and pinions be employed. If the first of these fractions, or its equivalent, $\frac{7}{77}$, be taken, the wheel attached to Jupiter's tube should contain 77 teeth, and the pinion attached to the annual arbor by which it is driven should contain 7 leaves, and Jupiter's radius will then revolve once during 11 revolutions of the annual arbor, that is, in 365·2564 × 11 = 4017·8204 days, which is less than the true period by 314·7644 days. In the same manner may be found the time in which Jupiter's radius will revolve when any of the other fractions are taken, as under:—

$$
\begin{array}{rlll}
 & & \text{Period produced.} & \text{Error.} \\
 & & \text{days.} & \text{days.} \\
 & \frac{11}{1} = & 4017·8204 & 314·7644 - \\
 & \frac{12}{1} = & 4383·0768 & 50·4920 + \\
\overset{\text{days.}}{365·2564} \times & \left\{ \frac{83}{7} = \right. & 4330·897 & 1·688 - \\
 & \frac{344}{29} = & 4332·699 & 0·114 + \\
 & \frac{1115}{94} = & 4332·562 & 0·025 - \\
 & \&c. & \&c. & \&c.
\end{array}
$$

The third of these fractions, or rather its equivalent, $\frac{166}{14}$, was the one employed by Dr. Pearson in the construction of his new planetarium; so that in that instrument the wheel attached to Jupiter's tube contains 166 teeth, and is driven by a pinion of 14 leaves attached to the annual arbor. In the planetarium of the Royal Institution, a train of wheels and pinions represented by the compound fraction $\frac{111}{22} \times \frac{94}{40}$ was employed, which therefore gives a period of $365{\cdot}2564 \times \frac{111}{22} \times \frac{94}{40} = 4330{\cdot}778$ days.

The contrivance by means of which a true elliptic orbit may be produced is extremely simple. For this purpose all that is necessary is that the radius vector which connects the planetary ball with the superior extremity of the tube should consist of two parts or arms, the lengths of which have a determinate ratio dependent solely upon the eccentricity of the orbit, and that while the larger arm revolves about the *centre* of the ellipse by means of the wheelwork already described, the smaller arm be made to revolve about the extremity of the larger with the same angular velocity but in the opposite direction. This may be effected in two ways. By means of a pulley *fixed* to the planetary tube and connected by an endless silken cord with another pulley free to revolve about a vertical axle situated at the extremity of the larger arm. The effect of this connection will be that the latter pulley will revolve once during each revolution of the larger arm but in the opposite direction. If, therefore, the smaller arm be attached to this pulley it will revolve in the manner required. The same motion may be produced by employing a double pinion extending the entire length of the larger arm and communicating the rotatory motion given to it at one extremity, to the axle of the smaller arm situated at the other.

ORSELLIC ACID. [LICHENS, *Colouring matters of.*]

ORTHOGONAL, ORTHOGRAPHIC. The first of these terms, when not used in the same sense as the second, means simply perpendicular. Thus a curve cuts a set of curves orthogonally when it cuts them all at right angles.

Orthogonal or orthographic projection is that which is made by drawing lines from every point to be projected, perpendicular to a plane of projection. Thus if a plane were horizontal, and a point were to drop from a given position upon the plane, its last position would be the orthogonal or orthographic projection of its first.

ORTHOGRAPHY. When this word is looked at in its elements (two Greek words denoting *the art of writing* and *correctness*), it would seem that there ought to be included under it whatever belongs to the art of writing a language correctly, including both what is called etymology and syntax. But the grammarians have given it a restricted sense, and it is used to denote not the writing correctly in the general, but the proper selection of literal elements of each word that is used, and the proper division of each word when one part of it is at the end of one line and another at the beginning of the line which succeeds. In the ancient Hebrew manuscripts we may observe that this division of words never occurs, the scribes resorting to the expedient of widening certain of the letters, if in the ordinary form the words would not fill up the line. The law-stationers, in their copies of legal documents, fill up a line with a waved and unmeaning stroke, when the word which follows cannot conveniently be written in it at length.

We perceive by certain grammars and dictionaries published by practical men, both at home and still more in the United States of North America, that the writers appear to suppose that their works will be resorted to even by persons of cultivation as authorities or guides to orthography. But we believe it to be the case that the number is very few of persons who actually use dictionaries for this purpose. We mean, of course, not mere children or persons of very imperfect education; but even of those there are very few persons who read much and write occasionally, who ever think of resorting to books of the kind we are speaking of; while persons of a better education trust entirely to memory, and should a doubt arise, the reference would be made to some eminent author, and not to the guides of which we speak. In fact, the art is acquired almost without teaching, and is maintained in vigour through a whole life by the constant practice of writing and reading. At all events, there is no book, grammar, guide, or dictionary, which a scholar in England regards as in this point a book of authority.

Whether it would be expedient to raise some one work into an authority in such a point as this, is, in fact, a question—one of the greatest in philology that can be proposed—whether there shall be an invariable standard established to which a living language shall for ever conform. We doubt not only the possibility but the expediency of this; and in respect of orthography, we are quite sure that no such standard can be raised, because it would be quite impracticable to bring all persons who have a right to a voice in such a matter to an agreement in any one system involving the admission of certain fixed principles. The contemporary usage of persons of cultivation, meaning of a great preponderating majority, which will always exist, is, we apprehend, the authority to which each person who aspires to write correctly must continue to defer.

This has been the standard to which reference has always hitherto been made. Open any book printed in the reign of Queen Anne, and many words will present themselves in an orthography very different from that in which they would now be found. But we must not say that the persons who wrote them wrote incorrectly, if they wrote according to the practice of the cultivated persons of their time. If we ascend still higher, and go to the reign of Elizabeth, we find the orthography still more diverse from our own; and when we reach the time of Caxton, and still more when we go back to the days of Chaucer and Wycliffe, we find many words which, though they are actually words now in use, are so disguised in form that we can scarcely recognise them. We seem to have got among a people who spoke a different language, though they were our own forefathers, not more than some fourteen generations removed.

This has arisen from the want of a standard—something fixed, not varying like usage. There is an inconvenience in it as respects the writers before the time of Caxton and the invention of printing, and we may reasonably wish that, with reference to them, there had been some less varying standard and a continuous uniformity; but when we look in the writings of the men of the Elizabethan period, we find that, though now two centuries and a half have passed, there is no more difficulty in perusing them than there is in perusing the writings of our own day; and that the same will be the case in respect of the writings of the present day in the hands of Englishmen four or five centuries hence, may be safely foretold. So that there is no real prejudice arising from the unphilosophical and dangerous course of leaving this point to be regulated by anything so uncertain as contemporary usage.

At present the number of words of which the orthography is not uniform in all writings which aspire at once to be correct and devoid of affectation, is exceedingly small. Take this sentence, and the whole of the paragraph which precedes it; is there any word, except this word *precede*, in which any variety will be found in the ordinary current writings of the day? Or if we found a variety, should we not say that the deviation from the usual practice was a casual mistake, a slip of the press, an affectation, or that it was the result of some peculiar principle which some peculiar person had adopted? And even this word *precede*, though it belongs to a class in which orthography is not uniform, we should probably very rarely find written in any other way, for few persons would prefer the form *preceed*, if indeed such a form is ever used. So that practically a great and perhaps quite sufficient degree of uniformity and stability may be said to be secured under the regulating power which now exists.

Dictionaries and vocabularies, as affording an easy guide to the knowledge of what is the usage, may have their use in this respect to a few persons who write occasionally only; but as authorities, we repeat, they are of no avail.

It has been matter of complaint that the orthography of the English language is not more uniform; that is, that words which are composed in whole or in part of the same elements are not uniform in the manner in which those elements are exhibited. Thus all words derived of the Latin *cedo* with prepositions prefixed, it may be said, should be in one form; and it is a variety in defence of which nothing can well be pleaded that we should write *proceed* and yet write also *concede*. So with respect to such words as *honour*, *favour*, *odour*, *labour*, it may be said that there should be uniformity with other words like them, in which the *u* is not found; and further, that we should keep to the orthography of the Latin words of which they are forms equally in meaning and orthography. This appears plausible, but when it is considered that these words do not come to us *immediately* from the Latin, but have passed to us through the French, we recognise in the unnecessary letter *u* a part of the history of the word, which a person of true taste would scarcely be willing to relinquish for an advantage so trivial. Or take the rough word *through*: some may think that the three last letters may well be dispensed with, but they remain a pleasing evidence of the origin of the word in the rough and strong speech of our Saxon ancestors.

These little irregularities in orthography, like irregularities in other parts of grammar, are not to be regarded as evils. Such irregularities give birth to what are called *idioms*, in which no small part of the beauty of a language lies.

Attempts have, however, been made by ingenious men to introduce a greater degree of uniformity into our orthography. There is a treatise on the management of bees, printed about two centuries ago, in which we have a peculiar orthography on a system of the author's own. Ritson, in the last century, in some of his works adopted an orthography of his own. Professed writers on grammar have done the same; some of them to such an extent that the language, as written by them, can scarcely be known to be English. A more moderate reform is attempted by an American writer, Dr. Noah Webster, the author of the English Dictionary, which has been reprinted in this country; and Mr. Bromby of Hull, a learned and ingenious clergyman, has printed for private circulation a translation of the treatise of Plutarch concerning music, in which the orthography is regulated by certain principles which he lays down in the preface. Again, some gentlemen, distinguished alike by intelligence and philanthropy, a few years ago brought forward a well-considered form of alphabet, and gave to the world an example of it in the periodical called the 'Fonetik Nuz.' It would be well, perhaps, if philological inquirers and mission, aries availed themselves of this notation, when dealing with unwritten languages, or with those whose alphabets differ wholly or widely from all that is familiar to Europeans. Further, it may be conceded that the acquisition of the English language itself by young children would be greatly facilitated by the use of school-books on the "Fonetik" system as stepping-stones to our ordinary form of printing. No doubt it is some slight evil that the strict reduction of our written signs to harmony with spoken language would involve a sacrifice of much that is valuable for etymological guidance. But any loss on this side would be more than compensated by the increased facilities for attaining the language. The valid objection to the proposal is, the utter impossibility of effecting so extensive a revolution. It is most true, and it is also a serious evil, that our mode of spelling is so anomalous and inconsistent; yet the words are in reality very few of which the orthography may not be said to be now *established* by the great *Jus et Norma Loquendi*—custom. We take the following from a modern grammar, as being those which, in the opinion of the writer, are most frequently found with orthographical varieties:—

honour	honor
inquirer	enquirer
negotiate	negociate
control	controul
expense	expence
allege	alledge
complete	compleat
connexion	connection
abridgment	abridgement
surprise	surprize

Of course some of these represent classes. But what are these to the great body of such a language as ours? And with respect to the first and to the last, each of which represents a large family of words, we would submit that very few persons indeed who were entitled to a voice in a question of this kind would be found writing *honor;* and that there is a general rule respecting words in *ise* or *ize.* The rule is this: when the word is a derivative of the French *prendre*, as is the case with *surprise, enterprise,* and one or two others, to write it with the *ise;* but when it comes to us from the Greek, as in *agonize*, and other words, to keep the Greek termination *ιζω—Anglicè, ize.*

ORUS, or **HORUS**, an Egyptian deity, the son of Isis and Osiris, corresponds, according to Herodotus, to the Apollo of the Greeks, and was the last of the gods who reigned in Egypt. (Herod., ii. 144; Diod., i. 44.) Typhon, after the murder of his brother Osiris, sought to kill Orus; but his mother Isis, according to Herodotus (ii. 156), committed him to the care of Leto, who brought him up in the moving island of Chemmis, which was in the lake Buto. The Egyptian priests, however, in this instance, as well as in many others, appear to have been anxious to assimilate the history of their deities as much as possible to that of the Greeks. Orus, from the death of Osiris stood forth as the avenger of his father; and when he had grown up, he made war upon Typhon, whom he defeated in several battles, deprived of the kingdom of Egypt, and, according to some accounts, put to death. (Diod., i. 25; Herod., ii. 144; Plutarch, 'De Is. et Osir.,' p. 358, Francfort, 1620.)

According to Diodorus (i. 25), Orus was killed by the Titans, and restored to life by his mother Isis, who conferred upon him immortality, and taught him divination and the healing art; a fable which Wilkinson thinks "explained by the historical fact of the priesthood of different gods having ruled Egypt before the monarchical form of government was established in the person of Menes and his successors." (Wilkinson, 'Ancient Egyptians,' iv. 397.) Little reliance, however, as he adds, is to be placed on what the Greeks relate of the deities of Egypt.

Orus is frequently represented as sitting in the lap of Isis, but more commonly standing in a boat along with other deities, and piercing the evil being, Typhon, who is in the water, either in the form of a man, or of a long serpent. Orus appears also to be represented in some bronzes in the British Museum, which depict a man trampling on the crocodile, since we know that the crocodile was one of the symbols of Typhon. The symbol of Orus is a hawk, who, sometimes in later works, is figured perched on an oryx: and the god himself is represented with the head of a hawk crowned with the pshent, or double crown of Upper and Lower Egypt. (Wilkinson, iv. c. 13; 'Egyptian Antiquities,' vol. ii. p. 306.)

ORYZA, the name by which rice was known to the Greeks and Romans, and which has been adopted by botanists as the generic name of the plant yielding that valuable grain. [ORYZA, in NAT. HIST. DIV.]

The rice plant is undoubtedly a native of India, from which country it has spread over a great part of the world, especially in Asia, where it forms the principal portion of the food of the inhabitants, but it has also from very early times been introduced into the southern parts of Europe. Theophrastus describes it in book iv. c. 5, with other Indian plants, and mentions it as growing in water, and that its inflorescence is like that of milium or panicum, and not in form of a spike. Rice is now extensively cultivated in North and South Carolina, and in Georgia; also in Italy and the south of Spain, and likewise a little in Germany. The perfect system of irrigation and tillage which was introduced into Italy at so early a period no doubt rendered the cultivation easy, as the climate is also sufficiently hot and regular.

As the summer temperature of many countries is high, it is easy to cultivate an annual like rice where water is abundant and irrigation easy; but as the summer temperature of most European countries is too low, and not long enough continued, and far from regular, it is hopeless to attempt the culture of a grain which requires so much heat, and which has the disadvantage, from the moisture arising from irrigation, of making a country unhealthy; but this is not the case in the rainy season of tropical countries, where the rice-field is not much more moist than the rest of the country. Its culture has been attempted in England, and a small crop was raised near Windsor, on the banks of the Thames. It has been hoped that the mountain rice, which is known to grow at considerable elevations in the Himalayan Mountains, might be suited to an English climate. This variety certainly requires a less degree of heat, but it seems to be forgotten that temperature is only one of the elements of climate, and that moisture may be supplied to a plant either by the soil or the atmosphere, and the latter may be moist when the former is comparatively dry. Rice is sown in the Himalayas only in places within the influence of the periodical rains, that is, from about the middle of June to the end of September. In some places it is irrigated, and in others it is not, but rain falls very frequently, and the air is almost always in a moist state, from being charged with moisture from the heated valleys, which is deposited on the mountains, when it reaches an elevation where it becomes cooled beyond the point of saturation. The temperature also is so uniform as not to vary 10° of Fahr. from 70° for three months. So in the Isle of France the mountain rice is cultivated only in the rainy season.

The rice so extensively cultivated throughout India (and the cultivation in China, as described by Sir G. Staunton, is very similar) depends upon rain or irrigation either from rivers or tanks. These Captain B. Hall ('Frag. of Voyages,' vol. iii. p. 88) describes in one situation, near Nundydroog, as spread over a valley, which was from six to eight miles across, and that they were used for irrigating myriads of rice-fields. The embankments are sometimes miles in length, and then of a waving snake-like shape. One valley was pointed out to Captain Hall, about a mile broad and forty miles long from end to end, which included between thirty and forty tanks, every intermediate square yard of the intermediate spaces being richly cultivated, while the surrounding country appeared to be condemned to perennial sterility.

Dr. Roxburgh states that he never saw or heard of an Indian farmer manuring in the smallest degree a rice-field; yet these fields have probably for thousands of years continued to yield annually a large crop of rice, on an average from thirty to sixty fold; even eighty or a hundred has been known. The best rice-fields are extensive open plains through which large rivers pass. The soil is generally of good depth; the best are those annually overflowed by the inundations, from which they necessarily receive some fertilising matter; but the greatest part of the rice lands depend on the rains only, and receive no help except from it and the air. The varieties of rice are innumerable; forty or fifty at least are described. They are divided by Dr. Roxburgh into two kinds: one, called in Telinga, *Poonas*, Sans., *Asoo*, is sown thick in June or July, and transplanted in about forty days, when the plants are about nine to eighteen inches high; the fields are then kept constantly wet; more or less flooded, as some sorts require very little water, while others require a great deal. When the grain is ripe, the water is drained off, and the crop cut down with the sickle; it is either stacked or trod out by cattle. The grain is preserved in pits dug in high ground and lined with the rice straw. The straw is stacked by the careful farmer for feeding his cattle during the hot weather.

The second division of cultivated rice is called *Pedder Worloo* by the Telingas. The grains are awnless, and both the unhusked and husked rice, in most varieties, is white and of excellent quality, though some require much water. In other parts of the country rice is divided, according to the seasons in which it is reaped, into that which ripens in the hot weather of spring, in the summer, or in the winter.

Buchanan states that two crops in the year from the same land do not yield much more than a single good crop would. But the seasons are so uncertain, and the latter crop so liable to fail, that they cultivate as much as possible for the first crop. This is reaped in the rainy season, when the straw cannot be preserved, and as rice-straw is almost the only food which the cattle have in many districts, there is an absolute necessity for sowing the second crop for fodder.

Rice is no doubt the grain which yields food for the largest portion of the human race, but even in India great numbers do not eat rice; in fact, in all the north-western provinces wheat is the principal crop, and the natives eat wheaten cakes, and have rather a contempt for rice-eating districts. It abounds, however, in nourishment, being composed almost entirely of fecula, that is, 96 per cent., and therefore cannot be baked into bread; but it is more easily cooked. It is light and wholesome, and easily digested, and might form a much larger portion of the diet in Europe than it does. Europeans in India eat it at breakfast as well as at other meals, and with fish as frequently as with their curries.

Of the kinds imported into England, the Carolina is the best, and is grown in the marshy grounds of North and South Carolina. The grains are shorter, broader, and boil softer than the Patna rice, which is the best Indian kind known in this country, though in India there are several superior varieties, as for instance the Rilibeet, which are much more esteemed there. In the year 1859, 3,692,023 cwts. were imported into England. The quantity retained for consumption in the United Kingdom was 1,761,865 cwts.; of the estimated value of 1,652,505*l.* The relative values may be judged of by the price of the Carolina rice being 20*s.* when the Patna was 17*s.*; Bengal white, 12*s.*; and the Cargo only 9*s.* 6*d.* The Cargo is a reddish-coloured, coarse, but sweetish grain, which is liked by the lower caste of natives of India.

OSCI, or OPICI, a people of ancient Italy, who seem to have been identical with the Ausonians, or Aurunci, and who inhabited the central part of the peninsula—from Campania and the borders of Latium to the Adriatic. Some ancient writers consider the Ausonians to be a branch of the Osci; others, as Polybius, have spoken of them as distinct tribes, but this appears to be an error. The names Opicus and Oscus are undoubtedly the same. Aristotle (' Polit.,' vii. 10) calls the country from the Tiber to the Silarus, Ausonia and Opicia; and other ancient writers extended the name much farther, to the Straits of Sicily, but the southern extremity of the peninsula appears to have been occupied by the Œnotrians, a Pelasgic people, who were conquered by the Lucanians and Bruttii. Cumæ, one of the earliest Greek colonies on the coast of Italy, was in the country of the Opici. There was an ancient tradition in Italy in the time of the historian Dionysius, of a sudden irruption of strangers from the opposite coast of the Adriatic, which caused a general commotion and dispersion among the aboriginal tribes. Afterwards came the Hellenic colonies, which occupied the whole sea-coast from Mount Garganus to the extremity of the peninsula, in the first and second centuries of Rome, in consequence of which the population of the southern part of the Italian peninsula became divided into two races, the tribes of aboriginal or Oscan descent, such as the Sabini, Samnites, Lucanians and Bruttii, who remained in possession of the highlands, and the Greek colonists and their descendants, who occupied the maritime districts, but never gained possession of the upper or Apennine regions. Such is the view taken by Micali and other Italian writers; but Niebuhr (' History of Rome,' vol. i.) describes the Sabini, and their colonies the Samnites, Lucanians, and other tribes which the Roman writers called by the general name of Sabellians, as a people distinct from the Osci or Opici. He says, after Cato and other ancient historians, that the Sabini issued out of the highlands of the central Apennines near Amiternum, long before the epoch of the Trojan war, and driving before them the Cascans or Prisci Latini, who were an Oscan tribe, settled themselves in the country which has to this day retained the name of Sabina. From thence they sent out numerous colonies, one of which penetrated into the land of the Opicans, and became the Samnite people; and afterwards the Samnites occupied Campania, and, mixing themselves with the earlier Oscan population, settled there, and adopted their language. But further on, speaking of the Sabini and Sabellians, Niebuhr admits the probability of their being originally a branch of the same stock as the Opici or Osci. Micali considers the Sabini, Apulians, Messapians, Campanians, Aurunci, and Volsci, as all branches of the great Oscan family.

The Greeks, being superior to the native tribes in refinement and mental cultivation, affected to despise them, and they applied to the native Italian tribes, including the Romans, the adjunct Opican, as a word of contumely to denote barbarism both in language and manners (Cato apud Pliny, xxix. 1); and the later Roman writers themselves adopted the expression in the same sense: " Osce loqui " was tantamount to a barbarous mode of speaking. Juvenal (iii. 207) says:

> " Et divina Opici rodebant carmina mures ; "

and Ausonius uses " Opicas chartas " to mean rude unpolished compositions. The Oscan language was the parent of the dialects of the native tribes from the Tiber to the extremity of the peninsula, Sabini, Hernici, Marci, Samnites, Sidicini, Lucanians, and Bruttii, and it was evidently a cognate dialect with the Latin; whilst in the regions north of the Tiber the Etruscan predominated. Livy (x. 20) mentions the Oscan as being the language of the Samnites. The older Latin writers, and especially Ennius, have many Oscan words and Oscan terminations. The Oscan language continued to be understood in many parts of Italy down to a late period under the empire. The ATELLANÆ FABULÆ doubtless originated with them, though probably Strabo is mistaken in asserting that they were performed at Rome in his day in the Oscan language. In the Social War, the Confederates, who were chiefly people of Oscan descent, stamped Oscan legends on their coins. In Campania and Samnium the Oscan continued to be the vulgar tongue long after the Roman conquest, as appears from several monuments, and especially from the Oscan inscriptions found at Pompeii, and the bronze tablet found at Agnone in northern Samnium, which gives a list of offerings at a dedication. (Micali, ' Storia degli Antichi Popoli Italiani,' ch. xxix., and ' Atlas,' pl. 120.

The Oscan race, like the Etruscan, appears to have been from the remotest times strongly under the influence of religious rites and laws (Festus, under the head ' Oscum '), and the primitive manners and simple morals of the Oscan and Sabine tribes, as well as their bravery in arms, have been extolled by the Roman writers, among others, by Virgil (' Æneid,' vii. 728–730), and Silius Italicus (viii. 526–529).

Concerning the scanty remains of the Oscan language which have come down to us, see ' Linguæ Oscæ Specimen singulare quod superest Nolæ in marmore Musæi Seminarii,' which is given by Passeri, in his ' Picturæ Etruscorum in Vasculis,' &c., Rome, 3 vols. fol., 1767–75; also Guarini, ' In Osca Epigrammata nonnulla Commentarium,' Naples, 8vo, 1830, where several Oscan inscriptions are found collected. Klenze, ' Philologische Abhandlungen,' 1839; and Mommsen, ' Unter-Italieni sche Dialekte,' 1850. For Niebuhr's views on the Opici or Osci, see his ' Roman History,' vol. i.

OSCILLATION and CENTRE OF OSCILLATION. When any system is slightly disturbed from its position of equilibrium, it either falls altogether or endeavours to recover the position which it lost. In the latter case the equilibrium is said to be stable, and in the former unstable. A pendulum hanging downwards is an instance of the stable kind, and the same pendulum, if it could be so nicely adjusted as to rest immediately over the pivot, would be of the unstable kind. [STABLE AND UNSTABLE.]

When a system endeavours to recover its position, it acquires some velocity in the process; so that, though it would rest at the position of equilibrium if that velocity were then destroyed, it is really urged through the position by the velocity acquired, and continues to depart from it on the other side until, by the forces which act to restore it to the position, all the velocity acquired has been destroyed. Repetitions of the same phenomenon then take place in succession, the body never remaining still when it has attained the position of equilibrium, since it never is in that position except when moving with the velocity acquired in its descent to that position. If then there were neither friction nor resistance of the air to help in destroying this velocity, it would be a universal law of mechanics that a system disturbed from its position of equilibrium would never recover it, but would make perpetual oscillations about it.

In the widest sense, the problem of oscillations includes most of those which occur in astronomy, optics, &c. The moon and planets add to their average motions small oscillations about their mean places: the tides consist of oscillations of the ocean about the uniform spheroid, which, but for the action of the heavenly bodies, would be carried round in the diurnal rotation of the earth; the phenomena of light are produced by the oscillations which take place in an elastic æther; those of sound by the oscillations of the air; and so on. Usually, however, the problem of oscillation refers to nothing more than the oscillations of a solid system, acted on by gravity, about a horizontal axis, the original departure from the position of equilibrium being but small; in fact, to the purely theoretical part of the problem of the PENDULUM, to which we shall here confine ourselves, giving the investigations in a brief form, since it is impossible, within our limits, to explain the numerous points alluded to with sufficient illustration for a learner.

Let a material point, a very small body, be attached by a string or rod without weight to an immovable pivot. In the position of rest the string hangs vertically: let us now suppose it removed out of the vertical position, and let go when it makes an angle α with the vertical. When t seconds have elapsed, let it make an angle θ with the vertical. The material point is acted on by gravity with a force which would produce an acceleration g (or 32·1908) feet nearly, in one second: if then l be the length of the string, $l\,\theta$ is the arc, through which the point must move before it arrives at the lowest point of its course, and we have by the well-known equations of motion,

$$\frac{d^2 . l\,\theta}{d\,t^2} = -g \sin\theta, \text{ or } l\,\frac{d^2\theta}{dt^2} + g\sin\theta = 0.$$

The first integration of this gives

$$l\left(\frac{d\,\theta}{dt}\right)^2 = 2g\,(\cos\theta - \cos\alpha),$$

since it is a condition that the motion began when θ was $= \alpha$. This gives

$$dt = -\sqrt{\frac{l}{g}}\;\frac{d\theta'}{\sqrt{(\sin^2\alpha' - \sin^2\theta')}}$$

α' and θ' being the halves of α and θ, and the negative sign being taken because θ' diminishes as t increases. The integration of this is facilitated by assuming $\sin\theta' = \sin\alpha' . \sin\phi$, which gives

$$\sqrt{(\sin^2\alpha' - \sin^2\theta')} = \sin\alpha' \cos\phi,$$

$$d\,\theta' = \frac{\sin\alpha' \cos\phi\,.\,d\phi}{\sqrt{(1 - \sin^2\alpha' . \sin^2\phi.)}}$$

$$dt = -\sqrt{\frac{l}{g}}\,.\,\frac{d\phi}{\sqrt{(1 - \sin^2\alpha' . \sin^2\phi)}}$$

$$= -\sqrt{g}\,.\left\{1 + \frac{1}{2}\,P^2 + \frac{1.3}{2.4}\,P^4 + \frac{1.3.5}{2.4.6}\,P^6 + \,..\right\}d\phi$$

where P stands for sin α' . sin ϕ. To find the time of a semi-vibration, this must be integrated from $\theta' = \alpha'$ to $\theta' = 0$, or from $\phi = \frac{1}{2}\pi$ to $\phi = 0$, that is, after change of sign, from $\phi = 0$ to $\phi = \frac{1}{2}\pi$. Now between these limits

$$\int \sin^{2n} \phi . d\phi = \frac{1 . 3 . 5 \dots . \overline{2n-1}}{2 . 4 . 6 \dots . 2n} . \frac{\pi}{2}$$

whence, changing the sign of the preceding and integrating each term by this formula, we find the time of a semi-vibration. Double this, to find the time of a vibration, which call T, and we have

$$T = \pi \sqrt{\frac{l}{g}} . \left\{1 + \frac{1}{4} \sin^2 \alpha' + \frac{1 . 9}{4 . 16} \underline{\sin^4 \alpha'} + \frac{1 . 9 . 25}{4 . 16 . 36} . \underline{\sin^6 \alpha'} + \dots \right\}$$

a very convergent series. If α' be small, we have, with an error of the second order only,

$$T = \pi \sqrt{\frac{l}{g}};$$

or the time of vibration of the same pendulum in different small arcs is very nearly independent of the lengths of the arcs; a result which might be obtained from the considerations given in the article ISOCHRONISM. To take in two terms of the series is very nearly equivalent to multiplying the preceding value of T by $1 + \frac{1}{16}\alpha^2$.

The number of vibrations in a mean solar day of the pendulum whose length is l, placed in a vacuum, is

$$\frac{86400\sqrt{g}}{\pi\sqrt{l}} \left\{1 - \frac{1}{16}\alpha^2\right\} \text{ very nearly.}$$

Oscillation, centre of.—Let a number of material points invariably connected together vibrate about a horizontal axis. It is required to find at what distance a single material point must be hung that it may vibrate in the same manner.

Let there be a number of material points, or infinitely small bodies, having the masses m, m', m'', &c., invariably connected with each other, and with an horizontal axis of rotation, their perpendicular distances from the axis being l, l', l'', &c. Let $M = m + m' +$, &c., be the sum of all the masses, and let k be the perpendicular distance of the centre of gravity of the whole from the axis. When the last-mentioned perpendicular distance makes an angle θ with the vertical, the moving force is $M g$ acting in the direction of gravity at the distance $k \sin \theta$, and acting with a moment of rotation $M g k \sin \theta$. Let ϕ be the angular velocity at the time in question, which becomes $\phi + d\phi$ at the end of a new interval dt; then taking the mass m into consideration, we have $l\phi$ for its actual velocity, and $l d\phi$ for the increment in the time dt, whence $m l d\phi$ is the actual momentum gained, $m l \frac{d\phi}{dt}$ the moving force which would produce that momentum. This force acting at the distance l, and perpendicularly to that distance, would exert a moment of rotation $m l^2 \frac{d\phi}{dt}$. Ascertain in the same way the moments of rotation of the other masses; then by the equivalence of the impressed and effective forces [VIRTUAL VELOCITIES] we must have—

$$m l^2 \frac{d\phi}{dt} + m' l'^2 \frac{d\phi}{dt} + \dots \qquad = M g k \sin \theta.$$

But ϕ is $-\frac{d\theta}{dt}$, thus written since $\frac{d\theta}{dt}$ is negative; if then we denote $m l^2 + m' l'^2 + \dots$ (which is the MOMENT OF INERTIA) by $\Sigma m l^2$, we readily deduce from the preceding

$$\frac{d^2\theta}{dt^2} + \frac{M k}{\Sigma m l^2} . g \sin \theta = 0.$$

The question of the motion of this system is now completely reduced to that of a simple pendulum; for if we compare the preceding equation with that of the motion of a simple pendulum, we find that the two would agree if the length (there called l) of the simple pendulum were $\frac{\Sigma m l^2}{M k}$ or:—any rigid system which makes oscillations about an horizontal axis, oscillates in the same manner as a simple pendulum, the length of which is the moment of inertia of the system with respect to its axis divided by the product of the whole mass and the distance of the centre of gravity from the axis. If in the line k or its continuation, a distance equal to $\frac{\Sigma m l^2}{M k}$ be set off from the axis, the moving extremity is called the centre of oscillation, as being that point in which the whole mass might be collected without any alteration of the law of oscillation.

Let G be the moment of inertia when the axis passes through the centre of gravity and is parallel to the given axis; then [MOMENT OF INERTIA] $\Sigma m l^2 = G + M k^2$, whence the distance of the centre of oscillation from the axis is $\frac{G + M k^2}{M k}$, or $\frac{G}{M k} + k$. Hence the centre of oscillation is always farther from the axis than the centre of gravity by $\frac{G}{M k}$. Let this be called h: we have then

$$h k = \frac{G}{M}.$$

Now G and M are independent of the position of the axis, G depending only on the masses and manner in which the masses are distributed about the centre of gravity, and M on the amount of the masses. If then a new axis of suspension were taken, distant by k from the centre of gravity on the other side, that is, if a new axis of suspension were taken passing through the first centre of oscillation, and if h' were the distance of the new centre of oscillation from the centre of gravity, we should have

$$h' h = \frac{G}{M}, \text{ but } h k = \frac{G}{M}, \text{ whence } h' = k:$$

that is, the old axis of suspension contains the new centre of oscillation, if the new axis of suspension contains the old centre of oscillation. This is generally expressed thus: the centres of suspension and oscillation are convertible. When the body is a continuous mass, the preceding investigations apply, but the integral calculus must be employed to determine G.

OSCULATION, a term used instead of contact by foreign writers. [CONTACT; TANGENT.]

OSCULUM PACIS. [PAX.]

OSI'RIS, one of the principal Egyptian deities, was the brother of Isis and the father of Orus [ISIS; ORUS], and is said by many writers to have been the first king of Egypt. His history is given in the first book of Diodorus, and in the treatise of Plutarch, 'On Isis and Osiris;' but it is probable that the genuine Egyptian traditions respecting this deity had been considerably corrupted at the time of these writers. According to their accounts however, Osiris was the first who reclaimed the Egyptians from a state of barbarism, and taught them agriculture and the various arts and sciences. After he had introduced civilisation among his own subjects, he resolved to visit the other nations of the world, and confer on them the same blessing. He accordingly committed the administration of his kingdom to Isis, and gave her Hermes to assist her in council and Hercules to command her troops. Having collected a large army himself, he visited in succession Ethiopia, Arabia, and India, and thence marched through central Asia into Europe, instructing the nations in agriculture and the arts and sciences. He left his son Macedon in Thrace and Macedonia, and committed the cultivation of the land of Attica to Triptolemus. After visiting all parts of the inhabited world, he returned to Egypt, where he was murdered soon after his arrival by his brother Typhon, who cut up his body into twenty-six parts, and divided it among the conspirators who assisted him in the murder of his brother. These parts were afterwards, with one exception, discovered by Isis, who enclosed each of them in a statue of wax, made to resemble Osiris, and distributed them through different parts of Egypt. This myth appears to allude to the fact mentioned by Herodotus, that Osiris was the origin of the mummy form. After leaving this world Typhon, or the evil principle, was overcome by his influence. For the various explanations of the myth of Osiris, see Wilkinson, 'Ancient Egyptians,' iv. 333, &c.

Both ancient and modern writers have differed considerably respecting the peculiar attributes and powers of this deity. He appears to have been the representative of the supreme beneficence. The worship of Osiris consequently was universal in Egypt—though, says Herodotus, it was not customary for all the Egyptians to worship the same god, every one paid adoration to Osiris and Isis. Wilkinson says that Osiris differed from most of the other Egyptian deities, inasmuch as they were regarded as human beings who were deified after death, whereas Osiris was a manifestation of deity in a human form; and this was "the profound secret revealed only to some of those who were initiated into the highest order of the mysteries." ('Ancient Egyptians,' iv. 317.) Many of the ancients believed that he represented the sun or the Nile; while his discovery of the vine and his expedition to India led others to identify him with Dionysus. (Herod., ii. 144.) Herodotus informs us (ii. 48) that the festival of Osiris was celebrated in almost the same manner as that of Dionysus. It appears however not improbable that the worship of Osiris was introduced into Egypt, in common with the arts and sciences, from the Ethiopian Meroe. We learn from Herodotus (ii. 29) that Zeus (Ammon) and Dionysus (Osiris) were the national deities of Meroe; and we are told by Diodorus (iii. 3) that Osiris led a colony from Ethiopia into Egypt.

Osiris was venerated under the form of the sacred bulls Apis and Mnevis (Diod. i. 21); and as it is usual in the Egyptian symbolical language to represent their deities with human forms and with the heads of the animals which were their representatives, we find statues of Osiris represented with the head or the horns of a bull, accompanied with the name Apis-Osiris (Wilkinson, iv. 347).

Osiris, in common with Isis, presided over the world below; his principal office as an Egyptian deity, was to judge the dead, and he is mmonly represented on rolls of papyrus as sitting in judgment on eparted spirits. His usual attributes are the high cap, the flail or hip, and the crosier; and he is clothed in white. Sometimes he is gured with a hawk's head. He is also frequently represented with an tificial beard. His titles are very numerous: Wilkinson notices me of the principal (iv. 320). By the Greeks he was identified with ionysus. But Diodorus says that some have supposed him to be luto, Pan, and even Zeus. The mysteries of Osiris, with which ere conjoined those of Isis, were practised with great secrecy and olemnity. It was from them that the Eleusinian mysteries were erived. (Diodorus, i. 29; Herodotus, ii.) The chief seats of his orship were Philæ and Abydos; at the former of which the great ysteries were celebrated.

OSMANOSMIC ACID. [Osmium.]

OSMIC ACID. [Osmium.]

OSMIUM (Os). From *οσμη, odour,* in allusion to the smell of smic acid. This metal was discovered by Mr. Smithson Tennant in he year 1803, in the grains of native platinum [Platinum], along ith another metal [Iridium]. This compound, called *osmide of ridium,* occurs in flat grains and hexagonal crystals. The primary orm is a rhomboid. Cleavage, perpendicular to the axis. Hardness ·5 to 5·1, exceeding that of native platinum. Colour iron-gray and ale steel-gray. Lustre metallic. Opaque. Specific gravity 19·5. Insoluble even in aqua regia; becomes black when fused with nitre, and when heated in a tube exhales a peculiar odour.

Berzelius analysed three varieties of osmide of iridium, from Siberia, with the annexed results.

Osmium	80	74·9	49·34
Iridium	20	25·1	46·77
Rhodium	..	..	3·15
Iron	..	..	0·74
Palladium	..	..	trace.
	100	100·0	100·00

The preparation and properties of osmium have lately been studied by MM. Deville and Debray. These chemists have obtained it in the pulverulent, crystallised, and compact forms, by the following processes. Osmide of iridium powdered, if necessary, by roasting with zinc, is mixed with five and a half times its weight of binoxide of barium and heated in a well covered crucible to the temperature of melting silver, for two hours. The resulting black mass is then broken up, distilled in a retort with eight parts of hydrochloric acid and one of nitric acid, the well cooled distillate redistilled, and the vapours condensed in dilute ammonia. The osmiate of ammonia solution thus formed is then saturated with sulphuretted hydrogen and boiled, and the sulphide of osmium reduced by heating for four or five hours, in a carbon crucible, to the temperature of melted nickel or melted rhodium.

Osmium thus obtained is *pulverulent,* but exhibits the metallic lustre with considerable brilliancy; has a blue colour brighter than that of zinc; a specific gravity of 21·3 or 21·4, and, at a temperature higher than that of melted zinc, is combustible. Heated to bright redness, with eight times its weight of tin, in a carbon crucible, and the melted mass allowed to cool slowly, it separates out in a *crystalline* form, and is isolated on dissolving out the tin with hydrochloric acid. Heated by the oxyhydrogen blowpipe, in a furnace made of lime, it does not fuse, but aggregates into a more or less compact mass, and at the heat of melted iridium is slowly dissipated in vapour.

Osmium combines with mercury; the amalgam is decomposed by heat, the mercury volatilising, and the osmium remaining behind in such a fine state of division as to take fire on coming into contact with air; in this condition also it is soluble in nitric acid, but is not so after ignition. In classifying the elements, osmium is usually placed next to arsenic; its equivalent is 99·41.

Oxygen and *osmium* combine in five proportions, forming:—

1. Protoxide of Osmium	OsO
2. Sesquioxide of Osmium	Os_2O_3
3. Binoxide of Osmium	OsO_2
4. Teroxide of Osmium	OsO_3
5. Osmic acid	OsO_4

1. *Protoxide of osmium* (OsO).—When potash is added to a solution of chloride of osmium, the protoxide is precipitated in the state of hydrate (OsO, HO), and is of so dark a green colour as to appear nearly black. This hydrate dissolves slowly in acids, forming dark green coloured solutions, which do not yield crystals by evaporation, but leave green or greenish-brown translucent residues. When the hydrate is heated rather below redness, it loses water. It detonates when heated with certain combustible bodies.

2. *Sesquioxide of osmium* (Os_2O_3) has not been procured in a separate state, but is obtained in combination with ammonia when the binoxide is heated with excess of that alkali; nitrogen is evolved during the operation by the decomposition of a portion of the binoxide and of the ammonia.

3. *Binoxide of osmium* (OsO_2) is formed and precipitated by pouring a solution of carbonate of soda into a saturated solution of bichloride of osmium and potassium. The precipitation takes place gradually, and after separating, by means of hydrochloric acid, a little soda which it retains, it is obtained in a state of purity; it is of a black colour and insoluble in acids.

4. *Teroxide of osmium* (OsO_3), *osmious acid,* is prepared from the terchloride in the same way as the binoxide from the bichloride. Its existence, however, is not perfectly established. A crystalline compound with potash ($KO, OsO_3, 2HO$) appears to exist.

5. *Peroxide of osmium,* or *osmic acid* (OsO_4).—This is a very curious compound, differing remarkably from all the preceding substances. It is obtained whenever osmium is burnt in the air or in oxygen gas, or when the pulverulent metal is heated with hot nitric acid. It is white, very volatile, extremely fusible, soluble in water, and crystallises in colourless transparent flexible needles. It possesses an extremely disagreeable odour, somewhat resembling that of chlorine. It combines with alkalies, forming compounds which are called *osmiates.* When sulphurous acid is added to a solution of osmic acid, it is rendered yellow, orange, brown, green, and blue, dependent upon the extent to which the deoxidisement is carried on. It stains the skin, is acid and poisonous.

Osmium and *sulphur* form four sulphides. They are produced on passing sulphuretted hydrogen through the hydrochloric solutions of the oxides. They much resemble the latter in constitution.

Osmium and *chlorine* form four chlorides, namely, *protochloride of osmium* ($OsCl$), which sublimes in green needles on passing chlorine over osmium heated in a long tube; *sesquichloride of osmium* (Os_2Cl_3), known only in combination with chloride of ammonium; *bichloride of osmium* ($OsCl_2$), formed by excess of chlorine in the preparation of the protochloride, but crystallising farther from the source of heat, and is red instead of green; and *terchloride of osmium* ($OsCl_3$), also known only in combination with chloride of ammonium.

Osmium and *nitrogen* form *osmiamic acid* (Os_2NO_5), according to Gerhardt, or *osmanosmic acid* (OsN, OsO_4), according to Fritzsche and Struve. It separates as a yellow crystalline powder on adding caustic ammonia to a solution of osmic acid in potash.

The remaining compounds of osmium have not been satisfactorily studied. They are all characterised by giving fumes of osmic acid, when heated with carbonate of soda on platinum foil in the blowpipe flame, and the fumes are recognised by their odour. Osmic acid also imparts luminosity to the flame of alcohol.

OSMOSE. The phenomena of liquid diffusion [Diffusion] become more complicated when the two liquids are separated by means of a porous diaphragm, because in such case there is adhesion between the liquids and the material of the diaphragm: nevertheless the liquids will mingle together in opposition to gravity. For example, if a funnel, furnished with a long narrow stem, and a piece of moistened bladder tied over its mouth, be filled with spirit of wine or with syrup, and be placed in a shallow vessel of water, the liquid will in a few hours rise in the tube, and even overflow. In this case there is a greater adhesion between water and the membrane than between spirit and the membrane; hence the water in contact with the lower surface of the membrane rises into it by capillary attraction, and gains the upper surface where diffusion of the water through the spirit sets in, and is promoted by the adhesion existing between the two liquids. In this way the liquid within the funnel increases in bulk, and fills and even overflows the tube. This flowing in of the liquid was termed by Dutrochet *endosmosis,* from *ενδον* "inwards," and *ωσμος* "impulse." While this force is acting from without inwards, a small quantity of spirit is passing out into the water below, which process of flowing out is termed *exosmosis.* If two other liquids be selected the phenomena will be produced, provided one liquid adhere to the bladder more perfectly than the other, and the two liquids have a certain degree of adhesion for each other.

Graham ('Phil. Trans.,' 1854) has investigated the subject, which is one of great interest, physiologically as well as chemically. The instrument used in his experiments is termed an *osmometer*: it is formed of a bell-glass of five or six ounces, having a plate of perforated zinc over its open mouth, and outside this is securely tied a piece of fresh ox-bladder with the muscular coat removed; or else an artificial membrane of calico soaked in white of egg, and dipped in boiling water to coagulate it. A tube $\frac{1}{10}$th of the diameter of the mouth of the bell-glass, is fitted into an aperture at its top, and is graduated into millimetres, each degree being about $\frac{1}{25}$th of an inch. A rise or fall in the liquid in the tube, amounting to 100 millimetres, represents the entrance or removal of a stratum of liquid 1 millimetre thick over the surface of the membrane. The saline solution to be examined is placed in the jar, until it stands at a fixed mark in the tube. The jar is then placed on a tripod within a tall cylinder, into which distilled water is poured up to the level of the liquid in the tube, and this level is maintained during the experiment by adding or removing water from the outer jar. In this way it was found—1. That neutral organic substances, such as urea, gum arabic, sugar of milk, gelatine, and salicin, exert little or no osmotic action. 2. That strictly neutral salts, such as sulphate of magnesia, chloride of sodium, and chloride of barium, have no peculiar osmotic action, but follow nearly the same rate of diffusion as when no diaphragm is used. 3. That alkaline solutions, especially those of potash and soda, produce energetic osmotic results: dilute solutions containing not more than 2 per cent. of the salt, answered best; but the effect was observed when 1 part of the salt was contained in 1000 of water; and while a large bulk of water entered the osmometer, only a minute portion of the alkaline salt escaped into the water of the outer jar. Thus, with a solution of carbonate of potash (1 part salt to 1000 water) in the osmometer, the liquid rose in the stem 192 divisions in five hours, and for each grain of carbonate of potash that was diffused into the outer cylinder more than 550 grains of water entered the osmometer. When, however, a solution containing 1 per cent. of carbonate of potash was used, only 63 grains of water entered the osmometer for each grain of carbonate that passed into the outer cylinder. When the liquid rises in the osmometer it is termed *positive osmose*. 4. That dilute acids and solutions of acid salts produce a current in the opposite direction, so that the column falls in the stem; this is known as *negative osmose*. Osmose is remarkably shown in salts which admit of division into a basic salt and a free acid. Acetate of alumina, nitrate of lead, chloride of zinc, and the salts of the sesquioxides of chromium and iron are good examples. In such cases the acid diffuses outwards, and the inner surface of the membrane remains in a basic condition while the outer surface is acid—conditions which are highly favourable to rapid positive osmose. 5. That in all cases of osmotic actions (except where alcohol and cane-sugar are concerned) the material of the diaphragm is chemically acted on, and if the diaphragm be made of a material not capable of decomposition by the liquids, such as gypsum, unbaked clay, tanned leather, compressed charcoal, although sufficiently porous, there is little or no osmotic action. The most favourable cases are those in which the chemical action on the diaphragm is different on the two sides both in degree and kind, as when one surface is acid and the other alkaline. 6. That two salts, when mixed, often exert an osmotic action very different from what they exercise separately. Thus, sulphate of potash has a feeble positive osmose, but a very minute addition of carbonate of potash increases its osmotic force fivefold, and a minute trace of hydrochloric acid arrests it. Chloride of sodium also reduces osmotic action in other salts.

The osmotic force must be distinguished from Diffusion; for in the latter case, if a saline solution were in the interior reservoir, liquid salt particles would ooze through the membrane, and a certain quantity of water would flow back and take their place; but if this were a case of diffusion the water would not be more than five or six times the weight of the escaping salt, whereas the water entering the osmometer may exceed the weight of the escaping salt 100 times or more. Nor can osmose be identified with capillarity. [Capillary Attraction and Repulsion.] Many of the saline solutions which exhibit the greatest osmose are not distinguishable in capillary phenomena from pure water. The force of the osmotic current may also be measured in the following manner, devised by Liebig:—Close the open end of the short limb of a glass syphon by means of a piece of bladder; pour a little mercury into the bend of the tube, and fill the shorter limb with the saline liquid. Immerse the bend of the tube and the membrane in water, leaving the extremity of the longer limb open; and as the water enters the tube the mercury will rise in the longer limb, and when the column reaches a certain height the two liquids will intermingle without change of volume. The length of the column which has been raised above the level of the surface of the mercury is to be measured, and this, when compared with the lengths of the columns obtained with other liquids, will give a comparative measure of the osmotic force in each case. Thus it will be seen that chemical affinity (shown by the action on the diaphragm) is converted into motive power, capable of numerical expression. It seems most probable that in the animal system there is an arrangement by which motive power is obtained from the decomposition of the tissues. All parts of living structures are in a condition of incessant change, decomposition, and renewal. It may one day be demonstrated that the osmotic injection of fluids is the associating link between muscular movement and chemical decomposition.

The flow of liquids through capillary tubes presents phenomena closely connected with diffusion. They are well discussed in M. Poiseuille's memoire ('Annales de Chimie,' 3 serie, xxi). They are also stated in a briefer form in Professor Miller's 'Elements of Chemistry,' part i., 2nd edition, 1860, where the following remarks occur:—"Osmotic phenomena are constantly going on both in plants and in animals; for in their tissues liquids of very different natures, sometimes acid, still more often alkaline, are circulating through vessels necessarily constructed of flexible and porous materials, and in the economy both of the vegetable and of the animal creation such actions are of the highest importance to the due performance of the vital functions. In fact, we as yet know not how intimately the entire processes of absorption, nutrition, and secretion are connected with the operations of liquid diffusion and of endosmosis."

OSSEIN. A peculiar kind of gelatin found in bones, horns, &c. It is insoluble in cold water, dilute acids, alcohol, and ether; but gradually soluble in boiling water, forming a jelly on cooling.

OSSIFICATION is the formation of bone. This process occurs naturally in the formation of the skeleton of man and the higher animals. [Bone, Nat. Hist. Div.] It also occurs in the reproduction of new bone after the destruction or loss of old bones. [Fracture.] Ossification occurs as an unnatural or morbid process. It is observed in several tissues of the body. It is most frequent in the cartilages of the ribs, in which it almost constantly occurs in advancing years. In most persons bone begins to form in these parts after the fiftieth year; it sometimes commences between the ages of thirty and forty, but is often delayed to a much later period; and Harvey relates that in the body of Thomas Parr, who died in his 153rd year, the cartilages of the ribs were still flexible and soft. The change is generally earlier in men than in women, and it affects the cartilage of the first rib sooner than the rest.

Next to the cartilages of the ribs those of the windpipe are most liable to become osseous. Ossification of the cartilages of the ear, nose, and Eustachian tube is, on the contrary, extremely rare, and in the few cases in which it occurs it is not particularly connected with old age. The cartilages of the moveable joints never ossify.

The tendinous tissue is that which, next to the cartilaginous, is most subject to ossification. This change is not uncommon at the insertion of the tendons of muscles that are much exerted, and in the ligament of some fixed or scarcely moveable joints. Small pieces of bone are also not unfrequently formed in the dura mater; and these are one of the sources of incurable epilepsy. Bone is also sometimes formed in the fibrous coats of the spleen and liver.

Ossification occasionally takes place in the false membranes produced by acute inflammation of the pleura, and more rarely in those of the pericardium; and it is a common process in the adhesions which form between the heads of bones exposed by ulceration of their cartilages, producing the most fixed kind of anchylosis of the joints.

A few remarkable cases are recorded of ossification of the muscles. There is a skeleton in the museum of the College of Surgeons in London, in which it has taken place to such an extent that nearly all the bones must have been immovably fixed by the transformation of the tissues by which, in the healthy state, they are moved. In equally rare cases the crystalline lens, the vitreous humour, and some other parts, are found converted into bone.

In all these examples the material formed exactly resembles true bone in its minute structure and chemical composition. In other cases, as in ossification of the heart and arteries, the substance deposited is composed of carbonate and phosphate of lime, as bone is, but its particles have no definite arrangement. That which is called ossification of the heart is not an affection of the proper substance of that organ, but of its valves, in which earthy matter is sometimes deposited, so as to render them stiff and unyielding, and destroy the pliancy which is necessary for the performance of their functions. A deposition of earthy matter in any part of the substance of the heart itself is very rare. [Heart, Diseases of.]

The disease named ossification of the arteries consists in the deposition of plates or rings of hard earthy substance in their middle elastic coats. This deposition is preceded by that of a peculiar soft or opaque yellow substance, which becomes gradually hardened. The deposition of this yellow substance in the large arteries is so common that it is very rare to meet with the body of an adult in whom it has not taken place to a greater or less extent; and it not unfrequently commences in early childhood. The change to earthy matter does not commonly take place before the thirtieth year, and is very general after the sixtieth. The roughness and irregularity in the circulation which it produces in the large arteries and the ulceration of their lining membranes which often accompanies it, frequently produce serious symptoms. The same changes are frequent in the arteries of the legs, and the obstruction to the circulation which they produce generally gives rise, if life is sufficiently prolonged, to the affection called gangræna senilis. [Arteries, Diseases of.]

OSTRACISM, the name for a singular institution existing for some time among the Athenians. When any man became conspicuous by wealth or by power, from whatever source derived, and was in consequence thought likely to conceive plans of ambition dangerous to the public peace and the stability of the existing form of government, this institution enabled the Athenian people to send him for a time into exile, and thus rid themselves of the danger which they dreaded. It was done as follows:—When the occasion was thought to require it, a day was fixed at an ordinary meeting of the Athenian people, for the purpose of holding an *ostracism*. On that day a part of the market-place (ἀγορά) was railed in, ten different approaches being left to the part thus railed in. There was thus one approach for each of the ten Athenian tribes. By these approaches the citizens, distributed according to their tribes, entered the space within the rails, and there deposited, in urns provided for the purpose, their shells or bits of earthenware (ὄστρακα, *ostraca*, whence the name *ostracism*), marked with the name of the person whom they respectively thought it desirable to banish. The nine archons, together with the Proëdri and Prytanes, superintended, seeing that everything was done properly, and in the end counting the votes. First of all they counted the gross number, which it was necessary should be above six thousand, else there was no valid ostracism. (Heumann, 'De Ostracismo Atheniense.') If there were found to be six thousand votes, then they proceeded to count the numbers against different individuals; and the individual against whom there was the greatest number of votes was sentenced to ten years' banishment, or (changing the phrase) was *ostracised*. He was then obliged to leave Athens within ten days after the sentence, and unless a vote of the people recalled him before the expiration of that time, to stay in exile for ten years; a period subsequently reduced to five years. The goods of the ostracised person were not confiscated, neither was ostracism considered in the light of a punishment or accounted a disgrace. It passed for what it was,—a declaration of superior wealth, of superior influence, sometimes indeed of superior virtue, whose ascendancy the state dreaded.

It is well known that Aristides the Just was one of those on whom ostracism was inflicted. The story told by Plutarch of his writing down his own name for ostracism is also well known.

Ostracism was introduced into Athens by Cleisthenes after the expulsion of the Pisistratidæ (Ælian, 'Var. Hist.,' viii., c. 24); and Cleisthenes was the first victim. Themistocles, Cimon, Alcibiades, Thucydides, were all numbered among the ostracised.

As to the merits of such an institution as ostracism, there cannot be any great difference of opinion. That must be a bad form of polity which needs it, though under a bad form of polity it may be itself a good. The first object of the statesman is to construct a government proof against the wealth and power arising from the ordinary course of social development: if he fails in this, he must defend the government, even at the expense of partial evil. The Athenians took care to mitigate the severity of the banishment, so far as they could consistently with the object of it. "Though this institution," says Montesquieu, "may be so far a condemnation of popular governments, yet it is, on the other hand, well fitted to prove their mildness; and we should have perceived this, were it not that, exile being with us always a punishment, we have been unable to separate the idea of ostracism from that of punishment." ('Esprit des Lois,' book xxi., chap. 17.) Mr. Grote ('History of Greece') calls it "a wise precaution," as preventing the excesses of partisanship by showing decisively the sense of the majority of the community, and less likely to lead even the victorious party to any infringement of the constitution.

A similar institution is said to have prevailed in Argos, Miletus, and Megara. At Syracuse also it prevailed, and there bore the name *Petalism*, leaves (*πέταλα*) being used on the occasion of voting, instead of shells.

OSTROGOTHS, or Eastern Goths, a division of the great Gothic nation, were settled in Pannonia in the 5th century of our era, whence they extended their dominion over Noricum, Rhætia, and the Illyricum. [GOTHS.] About the year 482 or 483 A.D., their king Theodoric was serving as an auxiliary under the emperor Zeno, and distinguished himself in Syria. On his return to Constantinople, Theodoric, according to the statement of the historian Evagrius, fearing Zeno's jealousy of his success, retired into Pannonia in 487, where he collected an army, and in the following year marched into Italy, with all his tribe, men, women, and children, and, as appears, with the consent of Zeno himself, who wished to remove the Ostrogoths from his territories. He defeated Odoacer in various battles, took him prisoner, and some time after put him to death. Upon this event, Theodoric sent an ambassador to Anastasius, the emperor of Constantinople, who sent him in return the purple vest, and acknowledged him as king of Italy. It appears that both Theodoric and his predecessor Odoacer acknowledged, nominally at least, the supremacy of the Eastern emperor. For the rest of the history of the Ostrogoths see THEODORIC [in BIOG. DIV.], who established his dynasty over Italy, which is generally styled the reign of the Goths in that country.

OTHYL, COMPOUND OF. (See col. 23.)

OTHYL, HYDRIDE OF. (See col. 23.)

OUNCE. [POUND.]

OUTLAWRY. This term, which is derived from the Saxon *Utlagh* or *Uthlagh*, signifies an exclusion from the protection of the law. In English law it is a punishment consequent upon a flight from justice, or a contumacious neglect or refusal to appear and answer for a criminal transgression, in obedience to the process of a court of competent jurisdiction. By the laws of the Anglo-Saxons, continued after the Conquest, an outlaw, who was also called *laughlesman* (lawless man) and *frendlesman* (friendless man), lost his *liberam legem*, and had no protection from the frankpledge in the decennary in which he was sworn. A boy under twelve years of age, not being sworn to his law in the decennary, could not be outlawed; and for the same reason a woman who contumaciously refused to appear could not be outlawed, but was said to be *waived* (derelicta), and incurred the same penal consequences as an outlaw.

For centuries after the Conquest an outlaw was said "Gerere caput lupinum," and might be lawfully killed by any one who met him. It is stated in the 'Mirror' (cap. iv. sec. 4) to have been the custom for those who slew outlaws or wolves to "carry the heads to the chief place of the county or franchise, and there to receive a demi-mark from the county for each head, whether of an outlaw or a wolf." The 'Mirror' is a book of doubtful antiquity and authority, and this story of the reward for the heads of outlaws is probably fabulous, or at all events an exaggeration of the fact. Bracton (lib. iii., cap. 13), declares that an outlaw "might be killed by all, especially if he defended himself or ran away, so that it was difficult to take him; but that when once taken, his life and death were in the king's hands; and if any man then killed him, he must answer for it as in the case of any other homicide." That this practice and law prevailed in his time is further proved by another passage (c. 14), in which he says that a man who has been outlawed, but has become "inlagatus," or restored to his law by a pardon from the king, should take care always to "carry his pardon about with him wheresoever he may go, and have it ready in his hand to show, lest peradventure some person, not knowing that he has obtained the king's grace, should slay him as an outlaw." Fleta (lib. i., cap. 27), mentions the same law, and justifies it: "Utlagatus et waiviata capita gerunt lupina, quæ ab omnibus impunè poterunt amputari; merito enim sine lege perire debent qui secundum legem vivere recusant." Lord Coke says, "In the beginning of the reign of Edward III. it was resolved by the judges, for avoiding of inhumanity and effusion of Christian blood, that it should not be lawful for any man but the sheriff only (having lawful warrant therefore) to put to death any man outlawed, though it were for felony; and if he did, he should undergo such punishments and pains of death as if he had killed any other man; and so from thenceforth the law continued until this day." For this fact he refers to the 'Year Book,' 2 Ass. pl. 3. The 'Year Book' however, as cited, and another report of the same case in Fitzherbert's 'Abridgement,' tit. Corone, 148, contain no such resolution, and the case from which it is obvious that Lord Coke derived the above statement, is clearly an authority to show the continuance of the old practice. A man being arraigned for homicide objects to answer because the person with whose death he was charged had been outlawed for felony. The judges at first certainly appeared to think that it was not lawful for any one to kill an outlaw unless it were upon his resisting a bailiff who should attempt to arrest him. But after argument, they said they "must send to the chancery to inquire if the deceased had a charter of pardon, and search their own rolls to see if his outlawry has been reversed;" and they admitted the prisoner to bail in the mean time, telling him that if they found that there had been no pardon and no reversal of the outlawry, he would not be called upon to answer. This case therefore seems to show that Lord Coke prematurely claimed for the judges in the reign of Edward III. the merit of abolishing this barbarous practice; indeed so late as the reign of Philip and Mary, Staundforde, in his 'Pleas of the Crown,' mentions the above case, and speaks of the law upon this subject as doubtful. However, though the technical quality of homicide so committed may have been questionable, there is no doubt that the practice of killing outlaws like wild beasts had ceased long before Staundforde's time.

The consequences of outlawry are the forfeiture of goods and chattels universally. Where it takes place upon a prosecution for *treason or murder*, it amounts to a conviction and attainder of the offence charged, and therefore all the outlaw's real property, as well as his personalty, is forfeited. Where it takes place upon criminal prosecutions for other offences, or upon civil actions, the profits only of the defendant's lands are, during his life, forfeited to the crown. The outlaw, having neither the privilege nor protection of the law, is incapable of maintaining any action; at common law he cannot be a juror, as he is not "liber et legalis;" and he is expressly excluded from acting as such by stat. 6 Geo. IV., c. 50, sec. 3.

The consequences of outlawry being so highly penal, the law has at all times been careful that no person shall be outlawed without sufficient notice of the process of the court, and without satisfactory proof of his contumacy. He must be called or *exacted* in five successive county courts, or in five successive hustings, if in London; if he renders himself, the sheriff takes him. But if he does not appear at the fifth county-court or husting, judgment of outlawry is forthwith pronounced by the *coroners*, who are the judges for this purpose in the county-court, and by the recorder if the proceedings are in London (Co. Litt., 288 *b*; Dyer, 223 *a*, 317 *a*). Upon this return a writ of capias utlegatum may be issued into any county to arrest the defendant, and other process follows against his property. As an additional security that a man shall not be outlawed without notice of the process to which he is required to appear, the sheriff must make three proclamations of him in notorious places in the county a month before the outlawry shall take place.

An outlawry may be reversed by writ of error, in which the party may avail himself of errors either of law or fact; the slightest mistake in any part of the proceedings being sufficient to avoid the outlawry. It was formerly necessary to procure a pardon from the crown, by which the outlaw was restored to his law, and became "inlagatus." It has long been the usual course for the courts to reverse outlawries upon motion, justice being thus expedited and expense saved.

OUTWORKS, in fortification, is the term applied to the various works constructed outside the enceinte of a fortress. These may be either temporary, to take advantage of the ground and enfilade a besieger's works, or they may be permanent works established on heights and commanding ground which it is necessary to occupy.

OVAL, or as the name imports, egg-shaped, is the name given originally to such a form as the section of an egg presents, round, but not circular. In mathematics it has received some extension of meaning. Any curve, or isolated branch of a curve, which returns into itself, would be called an oval; perhaps even a figure of eight would receive the name.

The curve having for its equation

$$y=\sqrt{x(x-a)\ (x^2-b)}$$

(a and b being positive, and a less than b) has an oval extending from $x=0$ to $x=a$: but there is no curve whatever from $x=a$ to $x=b$, or from $x=-b$ to $x=0$. If a be small, the dimensions of the oval are small: and when $a=0$ the equation becomes

$$y=x\sqrt{(x^2-b^2)}$$

in which the oval has become a point (the origin), and is a *conjugate point* [Curve], an isolated point which is not on any continuous branch.

Some conjugate points have none but imaginary values of $dy:dx$, some have one or more finite values. Thus when $y=x\sqrt{(x^2-b^2}$, there is a conjugate point at the origin, and $dy:dx$ is then imaginary: but when $y=x^2\sqrt{(x^2-b^2)}$ there is also a conjugate point at the origin, but $dy:dx$ is 0. The meaning seems to be (as far as we can judge from a few instances) that when the oval during its diminution, has axes which preserve a finite ratio to one another, so that its tangents fall in all directions, the ultimate value of $dy:dx$ is imaginary. But when one of the axes diminishes without limit as compared with the other, so that, except near the ends of that axis, the tangents tend to assume one direction, there is an ultimate value of $dy:dx$ which defines that direction. If our surmise be correct, a double or triple value of $dy:dx$ at the conjugate point would indicate the evanescence of a star-shaped oval, or of one which tends to assume that form as it diminishes. But this, with other points relating to the singular values of algebraic functions, has yet to be fully considered.

OVALBUMEN. A name given to the albumen of the hen's egg to distinguish it from the albumen of blood (*seralbumen*) which differs somewhat from the former.

OVARIAN DROPSY. [Womb, Diseases of.]

OVATION. [Triumph.]

OVERSEER, an officer appointed by justices of counties or boroughs, for parishes under the 43 Eliz., 2, and for townships under the 13 & 14 Car. II., 12. They cannot be less than two nor more than four for one parish or township. Churchwardens are ex-officio overseers of the poor. The duties of a paid assistant-overseer are identical with those of an overseer, so far as they may be specified in the warrant of justices, appointing the former under the 59 Geo. III., 12, s. 7, on account of the amount of the population, the extent of the parish, or other difficulties, rendering the office of overseer onerous and troublesome. Before the passing of the Poor-Law Amendment Act, (4 & 5 Will. IV., c. 76) it was the business of an overseer as well to expend as to make out and collect the poor-rates. Where no select vestry existed, he was judge of the necessities of applicants for parochial relief, an appeal in case of refusal lying before magistrates in petty sessions. For an account of the abuses which arose from the trust the law formerly confided to overseers, see the article Poor-Law, and the report of the commissioners for inquiring into the administration of the poor-law, published in 1834.

The 4 & 5 Will. IV., c. 76, commonly known as the Poor-Law Amendment Act, limited the authority of an overseer of the poor, by transferring to a board of guardians such portion of his duties as related to ascertaining fit objects for parochial relief, the amount of relief to be given, and the manner of giving it. With such services he has now little to do. His first business on entering upon his office is to obtain from his predecessors the parish books and documents and to collect outstanding arrears of poor rates, if any. If he have reason to believe that any demand for money will be made upon him by the guardians, he should forthwith make a poor rate, which must be signed by a majority of the parish officers, allowed by the justices and published. A poor rate is due from every person assessed, immediately after it is published, and if any person refuse to pay the rate, after a proper demand made upon him, the same may be enforced by distress and sale of the goods of the defaulter. If there should be no goods to distrain upon, the defaulter may be committed to prison for three months, unless the rate be sooner paid. The rate may be appealed against at the next special sessions, after it is made, on the ground of inequality or incorrectness; and if the overseers have a good defence, it will be their duty to defend the rate at the sessions. If they have no valid defence, they should at once consent to the rate being quashed or amended by the justices, as the case may require. If it should be quashed they should then proceed to make a fresh rate, avoiding the errors which led to the quashing of the former rate.

An overseer is only to give relief to the poor "in any case of sudden or urgent necessity;" and, as soon as he is able, is to report to the relieving-officer his having given such relief. The relief may not be given in money, but only in articles of absolute necessity. At the end of each half-year the overseer will receive a notice from the district auditor, to attend him in order that his accounts may be examined and audited. He should take with him to the audit all his parish books, letters, and papers, to any of which reference may possibly be made. He is to manage and collect the rents of parish property, and he has various duties cast upon him by statute and by the general consolidated order of the Poor-Law Board, in connection with the annual election of a guardian, or guardians, for his parish. Those duties will be found fully set out in Mr. Glen's collection of Poor-Law statutes and Poor-Law Board orders; and are much too voluminous to come within the limits of the present article.

With regard to registration, his business is as follows:—On the 20th of June in each year, he will affix on the church door a notice, directing fresh claimants for votes to make formal claim in writing to the overseer on or before the 20th of July. His next step is to make out for each parish an alphabetical list of the names of all persons already in the register, together with those of all claimants. This list must be completed by the last day of July, and affixed on the church or chapel, and, if there be no church or chapel, in some conspicuous situation, on the two first Sundays in August. He must give copies of this list for a reasonable payment, if required. On or before the 25th of August, objections to votes may be received. An alphabetical list of objections is to be posted, as before, on the two Sundays next preceding the 15th of September. When the revising barrister holds his court, it will be the duty of the overseer to attend. His expenses arising from his duties connected with registration are defrayed from the poor-rate. So far with regard to registration of county voters. Overseers of a parish situated in a borough, by the last day of July, without any claims being made, must make an alphabetical list of persons having a 10*l.* qualification in respect to premises situated in their parish. A similar list of freemen must be made where freemen are entitled to votes. These lists must be fixed as above. Claims from persons omitted and objections are received on or before the 25th of August, and lists of these claims, &c., are to be posted on the two Sundays next preceding the 15th of September. The forms according to which overseers are to frame their notices are to be found in the acts of parliament whence their obligations arise. The limits of this article do not admit of the duties of an overseer of the poor being further enlarged upon; the reader is therefore recommended to consult the publications of the learned gentleman before referred to, which are the standard works on the subject.

OVERTURE (*Ouverture*, Fr., *Sinfonia*, Ital.), a musical composition for a full instrumental band, introductory to an oratorio, opera, or ballet. An overture is a kind of musical prologue, and, as such, ought to be in good keeping with the piece which it ushers in; though in most instances but little attention has been paid to the character of this important feature of the melodrama. There are some exceptions, however, as in the fine overtures to 'Don Giovanni,' 'Der Freischütz,' and 'A Midsummer-Night's Dream,' all of which fully prepare the mind—in so far as inarticulate sounds can prepare it—for the romantic stories and supernatural agency of the following scenes.

The overture originated with Lully [Lully, in Biog. Div.], whose compositions supplied many of the early Italian operas with an opening instrumental piece. And indeed Handel himself imitated to a certain extent the overtures of the French composer; though in this case, as in every other of the kind, he improved whatever he touched.

Some good observations on the position and office of the overture will be found in an Essay by M. Fétis, entitled 'La Musique mise à la portée de tout le monde.' The author characterises Mozart's overture to 'Zauberflöte,' as a "chef-d'œuvre inimitable, qui sera eternellement le modèle des overtures et le désespoir des compositeurs."

OWNERSHIP. [Property.]

OXALAMYLIC ACID. [Oxalic Acid.]

OXALATES. [Oxalic Acid.]

OXALHYDRIC ACID. [Saccharic Acid.]

OXALIC ACID (HO, C_2O_3+2Aq.) This acid was discovered by Scheele, in 1776. It occurs in several plants, as in the wood sorrel (*Oxalis acetosella*) hence the name *oxalic*, and in common sorrel (*Rumex acetosa*). In the juice of these plants, and in the roots of rhubarb, bistort, gentian, &c., it is combined with potash; in several kinds of lichens, it is found in union with lime. It occurs as a mineral compound in combination with oxide of iron, called *Humboldtite*. It is an ingredient also of several urinary calculi.

Oxalic acid may be obtained by several processes: first, by decomposing the natural superoxalate of potash, or salt of sorrel, by means of acetate of lead, sulphuric acid, &c.; but it is best obtained by heating organic matter, such as sugar, potato starch, or even sawdust, with nitric acid in a retort. Having been first obtained from sugar it received the name of *saccharine acid*. Indeed most organic compounds which contain much carbon and no nitrogen, may be converted into oxalic acid by the action of nitric acid; hydrate of potash, in some cases, produces similar results, and this process applied to sawdust now yields much of the oxalic acid used in commerce. When nitric acid acts upon sugar or starch or sawdust, it is decomposed, and yields nitric oxide gas in great quantity; the oxygen of the decomposed acid uniting with the carbon of the vegetable matter, converts it into oxalic acid: the crystals first obtained are to be dissolved in water and re-crystallised to render them perfectly pure.

Oxalic acid crystals are prismatic, colourless, and transparent; the primary form is a right rhombic prism. Their taste is extremely sour, and they are very poisonous. When dissolved in 200,000 times their weight of water, the solution reddens litmus paper. Exposed to a dry air, oxalic acid effloresces, losing water of crystallisation; it dissolves in 15 parts of water at 50°, and in 9 parts at 60°; at 212° it melts in its water of crystallisation; it is soluble also in alcohol, but less so than in water.

Oxalic acid is usually considered to be monobasic, but most of its properties are those of a member of the dibasic series.

No means have yet been discovered of forming oxalic acid by combining carbonic oxide and carbonic acid; but when oxalic acid is heated with sulphuric acid, it resolves into these substances entirely, and in the proportions stated, the water which it contains combining with the sulphuric acid.

Oxalic acid contains water that cannot be totally expelled by heat; the acid, unless combined with a base, always retaining one equivalent.

Oxalic acid is to a certain extent volatile, and Mr. Faraday has shown that sublimation takes place even at common temperatures; at 212° the volatilisation is much more considerable; and when deprived of two-thirds of its water of crystallisation, it sublimes rapidly and without decomposing; the sublimed acid is crystalline, and contains one equivalent of water.

When oxalic acid retaining the whole of its water of crystallisation is suddenly heated up to about 300°, it yields carbonic acid, carbonic oxide, formic acid, and water.

Oxalic acid forms compounds with bases, which are termed *oxalates*, and of these we shall describe some of the more important.

Oxalate of ammonia. [AMMONIUM, *oxalate of ammonia.*]

Binoxalate of ammonia may also be formed, but it is not of importance. When binoxalate of ammonia is heated it yields *oxamic acid* ($C_4H_3NO_6$).

Oxalate of potash ($KO, C_2O_3, Aq.$)—Oxalic acid forms three salts with potash: the *neutral oxalate* is obtained by saturating the acid with the alkali. It crystallises in flat rhombic crystals, which are so very soluble in water, that even when cold the latter takes up half its weight. When a solution of oxalic acid is added to this, precipitation of a less soluble supersalt occurs.

Binoxalate of potash ($KO, HO, 2C_2O_3 + 2Aq.$) may be prepared either by dissolving the requisite quantities of acid and alkali in water, or, as above mentioned, by adding oxalic acid to the neutral salt. It forms small rhombic crystals, which have a bitter taste and an acid reaction; they are soluble in about 10 times their weight of cold water. This salt, mixed with the quadroxalate, exists in *oxalis acetosella,* and they constitute the compound know by the name of the *salt of sorrel,* or *salt of lemons,* employed for removing ink-spots.

Quadroxalate of potash ($KO, 3HO, 4C_2O_3 + 4Aq.$) may be formed by digesting the binoxalate in hydrochloric acid, which taking half the potash, the remainder becomes quadroxalate; or by saturating carbonate of potash with oxalic acid, and then adding three times the weight of oxalic acid already used. The crystals are prismatic, and are as little soluble in water as those of the binoxalate.

The oxalates of potash are all converted by a red heat into carbonate of potash; their composition was first ascertained and pointed out by Dr. Wollaston as affording one of the most remarkable series of proofs of the doctrine of multiple proportions.

Oxalate and binoxalate of soda may be formed, but they are not employed.

Oxalate of lime ($CaO, C_2O_3, 2Aq.$) is a very insoluble compound, and hence oxalic acid and lime, with certain restrictions, are used as tests of each other's presence. Baryta and strontia also form insoluble compounds with oxalic acid. The remaining metallic oxalates of importance are noticed under the respective metals.

Oxalic ether, or *oxalate of ethyl* $\left(C_4O_6\left\{\begin{matrix}C_4H_5O\\C_4H_5O\end{matrix}\right.\right)$ is best obtained by allowing a slow stream of absolute alcohol to flow into a retort containing oxalic acid in a state of fusion, and from which the water has been mostly driven off. The distillate is washed with water, in which it is only slightly soluble, and finally dried over chloride of calcium. Its specific gravity is 1·0929; vapour density, 5·1; boiling point, 363·2° Fahr. It is miscible with alcohol or ether. Potash and soda decompose it, and ammonia converts it into *oxamide.* Potassium transforms it into carbonic ether with evolution of carbonic oxide.

Amyloxalic acid, or *oxalamylic acid* $\left(C_4O_6\left\{\begin{matrix}C_{10}H_{11}O\\H\ O\end{matrix}\right.\right)$ is formed on treating amylic alcohol with excess of oxalic acid.

Tests for oxalic acid.—The best is the production of a white precipitate (oxalate of lime), with any soluble calcium salt, insoluble in acetic acid, but soluble in hydrochloric acid.

OXALIC ACID, the most highly oxygenated of all the vegetable acids, is also the most rapid and certainly fatal of any which are capable of being crystallised. As the crystals are not unlike those of the sulphate of magnesia, or Epsom salts, mistakes between the two are of very frequent occurrence. Being likewise much used in the arts, and commonly known by the name of *acid of sugar,* it is taken either accidentally, or under the supposition that it is akin to sugar, and therefore pleasant and innocent.

To prevent confusion of the crystals of this formidable acid with those of the sulphate of magnesia, it has been proposed that the former should be coloured while in the course of preparation, an expedient which has not been adopted. But on the other hand, the crystals of Epsom salts have been manufactured of a different shape by a peculiar process of crystallisation. The taste is very different, a solution of oxalic acid being intensely sour, while that of sulphate of magnesia is extremely bitter. Attention to this point, in previously tasting a small quantity, may prevent very serious casualties. Oxalic acid not only acts with violence, but produces nearly the same effects to whatever texture of the body it is applied. The concentrated acid, if taken in considerable dose, may cause death in from two to twenty minutes. "After death the stomach is found to contain black extravasated blood, exactly like blood acted on by oxalic acid out of the body; the inner coat of the stomach is of a cherry-red colour, with streaks of black granular warty extravasation; and in some places the surface of the coat is very brittle and the subjacent stratum gelatinised. Such are the effects of the concentrated acid. When considerably diluted the phenomena are totally different. When dissolved in twenty parts of water, oxalic acid, like the mineral acids in the same circumstances, ceases to corrode; but, unlike them, it continues a deadly poison, for it causes death by acting indirectly on the brain, spine, and heart. The symptoms then induced vary with the dose. When the quantity is large, the most prominent symptoms are those of palsy of the heart; when less, fits of violent tetanus; and when still less, the spasms are slight or altogether wanting, and death occurs under symptoms of pure narcotism, like those caused by opium." Very few persons have recovered when the quantity taken was considerable. (Christison, 'On Poisons.')

To counteract the very rapid effects of this poison, the most prompt treatment is necessary. Chalk, magnesia, or even the plaster of the room diffused through water, should be given without delay. The other alkalies are improper, as they form soluble salts with the acid, and oxalic acid is an example of a poison which acts through all its soluble chemical combinations. Emetics may be given, if vomiting has not spontaneously taken place; but it is highly inexpedient to give much warm water, as dilution only facilitates the absorption of the poison, and induces its remote but equally fatal effects.

Notwithstanding the formidable properties of this acid, the agreeable cooling effects it displays have led to its employment in the form of lozenges, or in a dilute solution as a refrigerant. Both in this country formerly, and still in France, it is used to quench thirst, and allay the heat of the stomach, which prevails towards the later stages of consumption. But for this purpose citric acid or lemonade is preferable, as well as safer.

Besides the immediate danger from an over-dose, there is yet a remote source of risk which requires notice. Oxalic acid exists in many vegetables, in combination with lime or potass, or free, as in the case of the cicer arietinum. Many of these plants are used in different parts of the world, as salads, on account of their refrigerating quality. Their frequent employment by persons disposed to calculous diseases is highly dangerous, as they give rise to the formation of the mulberry or oxalate of lime calculus, which is not only the most painful of all the stones found in the human kidneys or bladder, but also the most insidious, for, owing to the insolubility of this compound, no deposit or sediment is observed in the urine at an early period, so as to occasion a suspicion of what is taking place. (Majendie, 'On Gravel,' 2nd French edit.) [CICER.]

The now well-ascertained connection between the existence of the oxalic acid diathesis, rheumatism, indigestion, and other painful diseases, renders a popular knowledge of this point of much importance. Not only the free use of some of the vegetables alluded to, but saccharine fruits, sugar, and starch, especially potato starch, give rise to the formation of oxalic acid, and its attendant evils. Rhubarb (*stalks,* not *powder*), sorrels of different sorts, tomatoes, common barberry, should all be avoided by persons prone to rheumatism or stone in the bladder. Hard waters, containing lime, should be eschewed. The excessive use of sugar, either in the ordinary states, or in sweet preserves, is improper. Where any calculus of this sort is detected in the bladder, the employment of bicarbonate of potass in solution gives great relief, by coating the very angular stone with a smooth surface. Its use must not be too long persevered in. (See 'Prout on Stomach and Renal Diseases.')

OXALMETHYLOVINIDE ($C_{10}H_8O_8$). *Oxalate of ethyl and methyl.* An ethereal salt of oxalic acid containing both ethyl and methyl. Its constitution is similar to that of oxalic ether. [OXALIC ACID; *Oxalic Ether.*]

OXALOVINIC ACID. [ETHYL; *Ethyl-oxalic Acid.*]

OXALURANILIDE. [URIC ACID.]

OXALURIC ACID. [URIC GROUP.]

OXALYL (C_2O_2). The hypothetical organic radical contained in oxalic acid, which is generally regarded as the hydrated oxide of oxalyl: $\left.\begin{matrix}C_2O_2\\H\end{matrix}\right\}O_2$ or $\left.\begin{matrix}(C_2O_2)_2\\H_2\end{matrix}\right\}O_4$.

OXAMELANILE ($C_{30}H_{11}N_3O_4$). *Melanoximide.* An unimportant organic compound, produced by the transformation of cyano-melaniline under the influence of acids.

OXAMETHANE ($C_8H_7NO_6$). Synonymous with oxamate of ethyl.

OXAMETHYLANE ($C_6H_5NO_6$). Synonymous with oxamate of methyl.

OXAMIC ACID. [OXALIC ACID.]

OXAMIDE ($C_4H_4N_2O_4$). A white pulverulent organic compound produced by the action of heat upon oxalate of ammonia. By the similar action of heat upon the oxalates of the artificial organic bases, a number of bodies analogous to oxamide are produced. The following may serve as examples:—

Dimethyloxamide	$C_8H_8N_2O_4$
Diethyloxamide	$C_{12}H_{12}N_2O_4$
Diamyloxamide	$C_{24}H_{24}N_2O_4$
Phenyloxamide or oxanilamide	$C_{16}H_8N_2O_4$
Diphenyloxamide or oxanilide	$C_{28}H_{12}N_2O_4$

OXAMYLANE ($C_{14}H_{13}NO_6$). Synonymous with oxamate of amyl.

OXANILAMIDE. [OXAMIDE.]

OXANILIC ACID ($C_{16}H_7NO_6$). *Phenyl-oxamic Acid.* An organic acid analogous to the oxamic acid, containing phenyl in the place of one equivalent of hydrogen.

OXANILIDE. [Oxamide.]

OXIDATION. The chemical process of uniting with oxygen; see Combustion; Eremacausis; Oxygen.

OXIDES. [Oxygen.]

OXYACANTHINE. An organic alkaloid of unknown composition, found along with berberine in the *Berberis vulgaris.*

OXYACIDS. [Salts.]

OXYBENZOIC ACID ($C_{14}H_6O_6$). An organic acid isomeric with salicylic acid. It is obtained by the prolonged action of nitrous acid upon benzamic acid. It is a colourless, crystallisable acid, forming salts which are termed *oxybenzoates.*

OXYCHLORIDES. Chemical compounds containing both chlorine and oxygen united with some other element or radical. Thus oxychloride of phosphorus PCl_3O_2.

OXYCOBALTIA. One of the ammoniacal compounds of cobalt. [Cobalt. *Ammoniacal compounds of cobalt.*]

OXYGEN (O), an elementary body, the properties of which are best known and most remarkable in its elastic or aëriform state, in which it is termed *oxygen gas.* The most important discovery of this substance was made by Dr. Priestley, on the 1st of August, 1774; and of his numerous contributions to chemical science, this is at once the most splendid and the most solid, and has rendered his name imperishable.

Dr. Priestley has stated, with his usual candour, that the discovery was also made, quite independently, though later, by Scheele, and he has refuted the unjust claim of Lavoisier to be also one of the discoverers of this element. To this gas Dr. Priestley gave the name of *dephlogisticated air*, Scheele called it *empyreal air*, and Condorcet *vital air.* Lavoisier gave it the name of *oxygen*, from the Greek words ὀξὺς, *acid*, and the root *γεν*, to *generate*, because he considered it as the sole cause of acidity; this appellation it still retains, although it is now well known that there are acids which do not contain it and alkalies which do.

Dr. Priestley first prepared this gaseous body by heating the binoxide of mercury, then called *mercurius præcipitatus per se*, in an air-jar, over mercury, by means of a lens, and he afterwards obtained it from other substances.

It is now prepared in various ways, according to the purposes to which it is intended to be applied. These ways we shall briefly state and explain, and also describe the production of the gas from the binoxide of mercury, first used by Dr. Priestley.

When mercury is heated, and at the same time exposed to atmospheric air, it is found that the volume of the air is diminished, and the weight of the mercury increased, and that it becomes, during the operation, a red crystalline body, which is the binoxide of mercury, formed by the metal combining with the oxygen of the air.

When this substance is subjected in a retort to a higher temperature than that required for its formation, the affinity between the metal and the oxygen is overcome; the former returns to its metallic state, and the latter to its gaseous form; and if added to the residual atmospheric air, its volume is restored.

If it be quite pure, and the operation be accurately performed, 216 grains (1 equivalent) of binoxide of mercury should be separated by the agency of heat into 200 grains, one equivalent of mercury, and 16 grains, two equivalents of oxygen, measuring 46·7 cubic inches.

By this process then oxygen gas is, though indirectly, obtained from atmospheric air: but there is a natural metallic oxide, the *binoxide of manganese*, which is found plentifully, and which also yields it by the mere application of heat, and the quantity of gas obtained is dependent upon the degree of heat employed; in this case, however, unlike that of the binoxide of mercury, the metal is not reduced. The equivalent of binoxide of manganese [Manganese] is 43·57, consisting of 27·57 of metal and 2 equivalents of oxygen = 16; and when 43·57 grains are heated to moderate redness in a coated glass retort, half an equivalent of oxygen, or 4 grains, measuring 11·67 cubic inches, are expelled, and there remains in the retort an equivalent of sesquioxide of manganese, composed of 27·57 metal and 12 oxygen = 39·57. But if the equivalent of binoxide be strongly heated in an iron retort, it is then converted into red oxide, consisting of one equivalent of metal, and one and one-third of oxygen, while two-thirds of an equivalent of oxygen are expelled, weighing 5·33 grains and measuring 15·56 cubic inches.

Another but less eligible method of obtaining oxygen from the binoxide of manganese, is to heat it with sulphuric acid in a retort; in this case an equivalent of the binoxide = 43·57, loses a whole equivalent of oxygen = 8 grains, or 23·35 cubic inches, and there remain in the retort protoxide of manganese combined with the sulphuric acid, forming protosulphate of manganese. It is to be observed that these statements of the quantities of oxygen procurable from a given quantity of the binoxide of manganese are made on the supposition of its being quite pure, which is hardly ever the case; the binoxide of commerce very commonly contains 20 per cent. of impurity.

Red oxide and binoxide of lead also, when heated, either with or without sulphuric acid, yield oxygen gas, but the quantity obtained is small, and the processes are on several accounts ineligible. When nitrate of potash also is heated to redness, it gives out a considerable quantity of oxygen gas, from the decomposition of the nitric acid; but as it comes over mixed at different periods of the operation with variable quantities of the nitrogen gas of the nitric acid, this is not a method usually resorted to.

The oxygen gas obtained from binoxide of manganese is sufficiently pure for all the usual purposes of experiments intended merely to illustrate the properties of the gas; but when the gas is required for chemical analysis or accurate investigations, it is then obtained from the salt formerly called oxymuriate of potash, but now chlorate of potash.

Chlorate of potash is composed of one equivalent of chloric acid 75·45, and one of potash 47 = 122·45; and when heated in a retort, is resolved into an equivalent of chloride of potassium 74·45, which remains in the retort, and 6 equivalents of oxygen, 5 from the acid and 1 from the potash = 48, which measure 140 cubic inches; so that there is scarcely any other substance which yields so much oxygen gas or of so great purity.

The evolution of the oxygen is greatly facilitated by mixing with the chlorate of potash about one-sixth of its weight either of binoxide of manganese or oxide of copper, and the process thus modified is now almost exclusively used for the preparation of oxygen gas.

Oxygen possesses great power of combination with other elementary bodies, there being only one (fluorine) with which it is not known to combine, either by direct union or indirect chemical action. The compounds to which it gives rise by combining with certain metals, and also indeed with some other bodies, may be classed under the three heads of oxides, acids, and alkalies. There are many bodies which, by a moderate degree of oxidation, become first oxides, and by an increased degree, acids; such substances are charcoal, phosphorus, chromium, &c.; but there is no instance of its forming with different proportions of the same element an acid and an alkali.

The properties of oxygen gas are, that it is devoid of colour, taste, or smell, and being transparent, it is also invisible. It possesses the mechanical properties of common air; it is capable of being respired, and a given volume of it will support life much longer than an equal bulk of common air; on this account the name of vital air was bestowed upon it. It is heavier than atmospheric air, 100 cubic inches at a medium temperature and pressure weighing 34·203 grains, whereas an equal volume of atmospheric air weighs 31·074 grains. It is but slightly soluble in water, requiring about 20 times its bulk for solution. Light has no effect upon this gas; by heat, like all gaseous bodies, it is merely expanded; and electricity is incapable of effecting any change in its properties. Oxygen gas has not been rendered either liquid or solid by the united agency of cold and pressure, and not having been divided into two or more kinds of matter, it is considered as elementary in its nature. Its equivalent, atomic or combining weight, is 8.

It will be proper here to notice the production of oxygen gas by the action of electricity, especially voltaic electricity, which, as is well known, possesses the power of evolving both oxygen and hydrogen from water. Oxygen gas is also evolved by the action of the sun's rays on the moistened leaves of trees, which by this agency decompose the carbonic acid diffused in the atmosphere from various sources, and by combining it with their carbon, flourish and increase in size. When compounds containing oxygen are decomposed by voltaic electricity, the oxygen is evolved in the gaseous state at the anode or positive pole.

The most remarkable property of oxygen gas, and that on account of which it was once called *Fire-air*, is the facility and splendour with which bodies, when previously ignited, burn in it. Substances which do not undergo combustion in the air, will readily do so, and with great brilliancy, in oxygen gas; iron for example burns very readily in it when previously made red-hot. The intensity of the light emitted by burning phosphorus in oxygen gas is such as to be scarcely tolerable.

In conclusion, we may remark, that until after the discovery of this gas nothing was or could be known respecting the nature of the air, of water, or of earth, all of which, formerly reckoned as elementary bodies, are now known to be compound, and to contain oxygen as one of their constituents. It has also thrown great and unexpected light on the nature of combustion and respiration.

The compounds which oxygen forms with metals and other elementary bodies, are treated of in the respective articles on those elements, whether they are oxides, acids, or alkalies. The importance of the oxygen of the air as affecting respiration, vegetation, combustion, and eremacausis, is fully enlarged upon under those words.

OXYGENATED WATER. [Hydrogen.]

OXYHYDROGEN BLOWPIPE. A jet of flame of very high temperature, produced by the combustion of mixed hydrogen and oxygen gases, as described under Drummond Light.

OXYLIZARIC ACID. Synonymous with *purpurin.* [Madder, *Colouring matters of.*]

OXYMURIATIC ACID. [Chlorine.]

OXYNAPHTHALIC ACID. [Naphthalic Group.]

OXYPHENIC ACID ($C_{12}H_6O_4$). *Binoxide of Phenyl; Pyrocatechin; Pyromorintannic Acid.* A colourless crystalline body, obtained by distilling catechu or morintannic acid. It is also contained in wood vinegar.

OXYPICRIC ACID. [Phenylic Group.]

OXYPORPHYRIC ACID. [Euxanthic Acid.]

OXYPROTEIN. [Protein.]

OXYPYROLIC ACID ($C_{14}H_{12}O_{10}$?). An organic acid, formed simultaneously with succinic acid when nitric acid acts upon sebacic acid.

OXYSYLVIC ACID. A resinous acid which has hitherto been only very imperfectly investigated.

OXYWATER. A name sometimes applied to binoxide of hydrogen. [HYDROGEN, *Binoxide of.*]

OYER AND TERMINER. These words in ancient law French denote a commission forming a court of criminal judicature, the distinguishing character of which is described by them. The substance of the commission, or *writ*, as it was anciently called, is an authority given by the crown to certain persons judicially to *hear and determine* (oyer et terminer) certain specified offences. The commissions of oyer and terminer are the most comprehensive of the several commissions which constitute the authority of the judges of assize on the circuits. On these occasions they are usually directed to the lord chancellor, several high officers of state, two judges of the courts of Westminster, the queen's counsel, the serjeants-at-law, and the associates; but (excepting on the northern circuit, where all the commissioners but one are of the *quorum*) the judges, queen's counsel, and serjeants are always of the *quorum*, so that the other commissioners cannot act without the presence of one of them. Justices of oyer and terminer have jurisdiction to inquire into the truth of all treasons, felonies, and misdemeanours committed within the several counties and places to which the commission extends, and also to *hear and determine* the same on certain days to be appointed by themselves. The issue of such a commission suspends all others, and hence magistrates cannot proceed under a commission of the peace at the same time. Besides these ordinary courts of oyer and terminer at the assizes, special commissions of oyer and terminer are sometimes issued where offences of a dangerous tendency have been committed in particular districts, and the public peace and security require immediate inquiry and punishment. So also special commissions have been sometimes issued where from particular circumstances the incompetency of the ordinary tribunals would occasion a failure of justice. A remarkable instance of this kind occurred when Mr. Dunning, afterwards Lord Ashburton, was recorder of Bristol and sole criminal judge under the charters of the city. A forgery of Mr. Dunning's name to a bill of exchange having been committed in Bristol, he refused to try a case in which he was a party interested, and it was therefore necessary to issue a special commission for the purpose of hearing and determining this single offence.

The Central Criminal Court is a court of oyer and terminer (and jail delivery) for the jurisdiction assigned to it by statute, comprising the metropolis and portions of the adjoining counties. The jurisdiction of the magistrates in quarter sessions is expressly preserved by the statute, for otherwise they could not hold courts at all.

OYSTER TRADE. The management of the oyster fishery presents many peculiar features. The best kind of oysters in this country are the small variety called *Natives;* they are found near the mouths of the rivers Colne, Blackwater, and Crouch, in Essex; the Swale and the Medway, in Kent; the Ouse, in Sussex; in Southampton Water; and at other places in all the three kingdoms. These artificial beds are usually supplied with the produce of the coast of Normandy, whence the spat or spawn is gathered. The spawn, when first cast, somewhat resembles in appearance a drop of fat; it is composed of an immense number of minute oysters, each of which becomes about a quarter of an inch long in three days, as large as a shilling in three months, as a half crown in six months, and as a crown in twelve months. They are stated to attain their highest degree of perfection when three years old. The oyster is found in the seas of most countries, but never at any great depth, and seldom far from the mouth of a river. The fishing for oysters is permitted from the 1st of August to the end of April.

The fishing, or, to use the more correct term, the dredging, is carried on to a large extent by small sailing- and row-boats—they usually dredge in company, as the oysters lie within comparatively small spaces. The dredge is a net on a wooden or iron frame, and is weighted according to the nature of the bed, varying from 12 to 18 pounds. It is thrown by one man, while another rows. The beds or banks are found in the British Channel; off the Isles of Wight and Jersey; on the coast of Wales; off the French coast. In Scotland they are found in the Frith of Forth; in Ireland, in Carlingford Bay, the oysters from which have a high character for excellence. France has also numerous artificial beds, but the fishermen also dredge in the Channel, where frequent disputes arise between them and the English fishermen respecting boundaries. The most esteemed natural beds in France are those off the coast of Brittany, at Dieppe, and Cancalle, near St. Malo.

So far as regards the London supply, the oysters are brought principally from the Essex coast and rivers; but the Milton, Feversham, and Burnham oysters are most highly esteemed. None are sent from the north of England; but broods are sent from thence to be fattened in the artificial beds. The sale at Billingsgate is enormous. At Southampton there is a wide margin of muddy shore at low water, on parts of which oyster-beds are formed. Oysters are brought from the Jersey fishery, laid down on those beds to fatten, turned and attended to every day, taken up when wanted, opened, placed in tin cans, and sent up to London by railway. These oysters are used for pickles and sauces, and not eaten in the ordinary way.

The oyster trade in England has been of considerable importance for centuries, and now ranks next to the herring-fishery. The dredging, the laying down spawn in the artificial beds, and attending to and gathering the oysters, and the packing for market, give employment to a large number of persons; while the rapid conveyance afforded by railways enable the inland towns to obtain oysters perfectly fresh and in excellent condition; and at Christmas the quantity transmitted in barrels as presents demands additional accommodation, not only from railways, but from every other means of inland transmission.

OZONE (from the Greek ὄζω, to smell) is the name given by Professor Schönbein of Basle to an odour evolved during the progress of certain electro-chemical decompositions. It is also produced by common electric sparks, and by the working of an ordinary electrical-machine in the air. This odour attracted no particular notice until M. Schönbein called the attention of the British Association to it in 1840, since which time it has undergone much examination, and various theories have been propounded as to its nature and composition.

Ozone is evolved at the anode, or positive pole of a galvanic battery, at the same time with oxygen, during the electrolisation of any of the following bodies: namely, water, dilute sulphuric acid, solutions of phosphoric and nitric acids, potash, and many oxysalts. Of these, dilute sulphuric acid mixed with chromic acid yields it in the greatest quantity. It may also be obtained from atmospheric air, by passing the electrodes through a closely-fitting cork into a jar filled with air, and frequently making and breaking contact. Under the influence of heat ozone disappears, and it cannot be obtained from heated solutions, or solutions of hydracids, chlorides, bromides, or iodides, the presence of which, even in small quantity, prevents its evolution from solutions otherwise yielding it abundantly. It may be developed by electrolising a solution of chloride of sodium with platinum electrodes, by placing the gas collected at the anode over ammonia and water to absorb the chlorine. Ozone can be preserved for a length of time with the oxygen collected with it in well-closed bottles. It possesses the property of bleaching litmus-paper and paper coloured with indigo or a solution of that substance. It is readily absorbed by mercury and the oxidisable metals, forming oxides with them; and when the solutions employed are heated, its affinity for metals is so greatly increased that it oxidises platinum and gold. Water absorbs it. The inspiration of ozone is very injurious, the effects being similar to those resulting from chlorine and bromine. A mouse is killed with it in five minutes; and M. Schönbein states that he was seriously affected by breathing an atmosphere charged with it.

The electrodes employed in these experiments have a great influence in respect to the evolution of ozone. With water or acid solutions they must be of platinum or gold; for when the more oxidisable metals are used it enters immediately into combination with them. It can be obtained from air when the positive electrode is copper, iron, silver, or platinum, and zinc negative, but not when these arrangements are reversed, or both electrodes are of zinc. On electrolising a solution of sulphuric acid the following results are obtained:—With platinum electrodes the odour is very powerful; but it is not produced when copper, zinc, or iron electrodes are employed. With boxwood charcoal, the gas given off from the positive pole has no smell; but when absorbed by lime-water it turns it milky, proving the gas to be carbonic acid. With gas charcoal, sulphuretted hydrogen is evolved at the negative pole and carbonic acid at the positive, but no odour of ozone is produced. With a solution of chloride of sodium, the odour is not perceptible until the gas obtained from platinum electrodes at the positive pole is placed over ammonia and water to absorb the chlorine. The residual gas emits the peculiar odour.

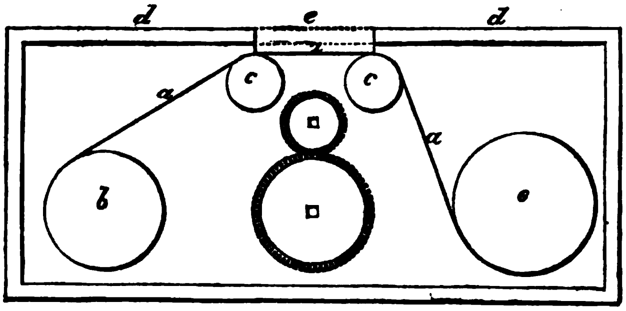
There exists much variance in the experimental results with this new substance, and not less in the opinions concerning its nature. Professor Schönbein and Dr. Andrews regard it as oxygen in an allotropic condition, whilst Dr. Williamson and M. Baumert consider it to be a teroxide of hydrogen. The latter chemist has even succeeded in analysing ozone, and thus quantitatively demonstrating its composition; nevertheless, Dr. Andrews calls in question the accuracy of these experiments, and adduces others in proof of his view of the composition of this substance.

Tests for Ozone.—Notwithstanding the remarkable characters of this body, no reliable test of its presence in minute quantity (in the air, for instance) is known. Paper imbued with starch and iodide of potassium is rendered blue by ozone, but the same effect is produced by acid gases; and this test, as used for the detection of ozone in the air, is utterly worthless. Paper soaked in solution of sulphate of manganese, which is turned brown, or impregnated with black sulphide of lead, which is bleached by ozone, are more reliable tests; but even these are open to so many sources of fallacy as to render their indications of little value. [HYDROGEN, *Teroxide of.*]

OZONOMETER, an instrument for measuring the quantity of ozone contained in the atmosphere. The only means of ascertaining the presence and quantity of this agent in the atmosphere, is founded upon the known action of ozone in decomposing iodide of potassium. If this salt be exposed to the action of an atmosphere containing ozone the latter unites with the potassium, forming oxide of potassium or potash, whilst the iodine is set free. In order to render this test obvious, the iodide of potassium is mixed with starch, and the iodine, when it is set free, unites with the starch, the existence of which is immediately ascertained by its blue colour: it is right, however, to add that the sufficiency of the test is not unquestioned. [OZONE.]

Schönbein, who originally described ozone, proposed this test and made use of it, by saturating paper with a solution of iodide of potassium and starch. As the result of using this paper was to indicate the quantity of ozone in the atmosphere by the intensity of the blue colour produced on the test paper, it was necessary for comparison to use the same test paper; hence Schönbein undertook to supply this paper from his own laboratory, and pieces of paper for every day in the year are sold in boxes under the name "Schönbein's ozone test paper." In this country Mr. Moffatt has distinguished himself by his researches in atmospheric ozone, and he also prepares a paper for supplying those who wish to measure the presence of ozone in the atmosphere. With these papers a scale of colour is supplied, each shade of colour showing the action of the ozone on the iodide and starch being marked from 0 to 10. In using this paper a slip is taken and exposed in some place to which the air has access, and there it is left for twenty-four hours. At the end of this time the paper is compared with the scale, and according to the intensity of its colour it is marked from 0 to 10.

Although this method indicates the existence of ozone at some time within the twenty-four hours, it fails to indicate the exact time at which the ozone was present, and prevents also any accurate comparison with other meteorological phenomena, as heat, wind, moisture,, &c. In order to render the registration of ozone more accurate, Dr. Lankester has invented an ozonometer, by which a strip of ozone paper 24 inches in length is exposed successively for an hour to the action of the atmosphere. In this way the ozone of each hour can be indicated, and the sum of its effect on the paper more easily ascertained. Dr. Lankester's instrument consists of a box (*fig.* 1): the iodised paper *a a a* is first carried round the wheel *b*, and passed on to the two cylinders *c c*. When the lid of the box, which is made of brass, *d d*, is down, it covers the whole box except a small space, *e e*, one inch in length and half an inch in width, which is cut in the lid, and through this the paper *a* is exposed to the action of the air. The strip, after this exposure, is carried from the cylinders *c c* to the wheel *e*, on which it is wound up. The machinery which moves the wheels is precisely similar to that of a clock, and the instrument is wound up in the same way. The following table will illustrate the method of registering the intensity of the ozone by this instrument:—



Section of Lankester's Ozonometer.

Hour, A.M.	Savile Row.			Blackheath.			Felixstow, Suffolk.		
	July 20.	July 21.	July 22.	Aug. 10.	Aug. 11.	Aug. 12.	Sept. 1.	Sept. 2.	Sept. 3.
12—1	0	0	0	2	0	5	4	3	2
1—2	0	0	0	3	0	4	5	3	5
2—3	0	0	0	4	0	3	3	4	4
3—4	0	0	0	3	1	2	6	2	3
4—5	0	0	0	2	2	3	2	1	2
5—6	0	0	0	1	3	4	2	1	2
6—7	0	0	0	2	4	5	3	1	3
7—8	0	0	0	3	0	2	3	2	3
8—9	0	0	0	4	0	1	4	3	4
9—10	0	0	0	2	0	0	5	4	2
10—11	0	0	0	1	0	1	6	2	2
11—12	0	0	0	0	2	2	4	1	3
P.M.									
12—1	0	0	0	1	4	1	4	3	4
1—2	0	0	0	0	2	0	2	4	5
2—3	0	0	0	2	1	2	4	5	3
3—4	0	0	0	1	1	3	3	4	2
4—5	0	0	0	0	0	4	4	3	2
5—6	0	0	0	3	0	5	5	2	3
6—7	0	0	0	4	1	2	4	2	4
7—8	0	0	0	2	2	4	4	4	2
8—9	0	0	0	0	3	3	2	3	1
9—10	0	0	0	2	2	1	2	2	2
10—11	0	0	0	3	4	2	3	4	2
11—12	0	0	0	2	0	1	2	2	3
	0	0	0	47	32	60	86	65	69

The results of ozonometric experiments show that ozone is seldom present in the atmosphere of great cities. It is generally present in air coming from the ocean, and in rural and mountainous districts, where the air is free from the contamination of animal and vegetable matter. On the sea-coast of Great Britain it appears to be more abundantly present than away from the sea. It has also been observed in larger quantities on the southern and eastern coasts of England when the wind blows from the south, or west, or south-west. As the wind veers from west to north, or from south to east, it diminishes.

P

P is the tenuis or thin letter of the labial series. For the various symbols employed to denote this letter see ALPHABET.

This letter is interchangeable with those which belong to the same organ, that is the lips, and with some others. Thus,

1. P is convertible with a *b*. The Latin, like the Welsh, was fond of the thin letters, in consequence of which there are very few words in that language which begin with *b*, while those commencing with *p* form a numerous class. It will often be found that the *p* in Latin words becomes a *b* in the related languages. Thus *apicula*, the diminutive of *apis*, a bee, is in French *abeille ; septem* is in German *sieben*. The German language often confounds *b* and *p*, more particularly when the former is final. Perhaps, too, even in Latin, the written *b* was pronounced as a *p* in the prepositions *ab, sub, ob*, which correspond to the Greek απο, ὑπο, επι.

2. *P* with *m*, somewhat rare. Thus the Greek preposition μετα is in the Æolic dialect πεδα. Again, the Greek μολυβδος is essentially the same word with the Latin *plumbus*. Allied to this change is the insertion of a *p* between either *m* and *s* or *m* and *t*, as in the Latin *sumpsi, sumptus*, for *sumsi, sumtus*, and *temptare* for *tentare*.

3. *P* with *v*. This change is more particularly to be observed in the derivation of French from Latin. Thus, from *capillus*, hair, *episcopus*, a bishop, *decipere*, deceive, &c., *aperire*, open, *opera*, work, *lepus*, hare, *pauper*, poor, *piper*, pepper, *Aprilis*, April, the French have deduced their *cheveu, evêque, decevoir*, &c., *ouvrir, œuvre, lièvre, pauvre, poivre, Avril*.

4. *P* with *f*. Two or three examples are given under F. To these may be added *pro, for ; pater, father ; piscis, fish ; pauci, few ; lupus, wolf*. So the Greek πορφυρα, φαινολη, Φοινιξ, have the aspirate, while the Latin, as usual, prefers the tenuis in *purpura, pænula, Poenus*.

5. *P* with *pf*. The latter form is often preferred by the German, where our own tongue has the single letter. Thus the English words *pound, peach, pepper, pea*-cock, *penny, apple*, are written by the Germans *pfund, pfirsche, pfeffer, pfau, pfennig, apfel*.

6. *P* with *c, k*, or *q*. See C.

7. *P* with *t*, as ταως, in Latin *pavo*. The Greek interrogative words beginning with a π, as που, πῃ, ποτερος, &c., are related on the one hand to the Ionic forms κου, κῃ, κοτερος, and on the other to the demonstratives that commonly take a τ at the beginning. And in fact the latter are often used as relatives.

8. *P* with *pt*. The latter is common in Greek, as in τυπτω, οπτομαι, &c., which form their other tenses for the most part without a τ. So too at the beginning of words. Thus πτολις and πτολεμος coexist with πολις and πολεμος; and it seems probable that it was an unsuccessful attempt to pronounce the initial *pt* which led to the formation of the Latin words *populus*, a state, and *populari*, to devastate with war.

9. *Ps* with *sp*. This change it will be more convenient to consider under the letter S.

10. *Pi* before a vowel with *ch*. Thus *sapiam*, in Latin, becomes *sache* in French. The word *roche*, too, was probably formed from a barbarous Latin word *rupia ;* and *Rutupium*, in the county of Kent, appears upon this principle to have changed its named to *Rich*borough.

PACE (*Passus*), a measure of the Roman system, being in fact their unit of itinerary measure, to which the *mille passus*, or MILE, was referred. The word *passus* is connected with the root of *pandere*, to extend, and Paucton curiously enough derives it *à passis manibus*, from the length between the extended hands, instead of *à passis pedibus*. There is however reason to believe that the mille passus came into use from the practice of measuring distances in new countries from the number of paces marched by the soldiery, of which a rough reckoning was kept, but whether by actually counting the paces, or by the time of marching compared with the previously known number of paces in a given time, is not known. It is well known that with disciplined soldiers either method would give very good practical results. Vitruvius describes a machine to be fastened to the wheel of a chariot (an invention revived in our own day), by which its number of revolutions was registered; but this was probably a late invention.

The pace was not, as persons in general suppose, the step or the distance from heel to heel when the feet are at their utmost ordinary extension; this, which the French metrologists call *pas simple*, was the *gradus* or *gressus*. The passus, or *pas double* of the same writers, was two gradus, or the distance from the point which the heel leaves to that on which it is set down. Assuming the Roman foot at 11·62 English inches, the pace, which was five feet, must have been 58·1 inches or 4·84 English feet.

Here we might have stopped, if it had not been necessary to explain something relative to what it pleased the writers of the middle ages to call the *geometrical* pace, composed of five geometrical feet. What they meant by this measure is not easily understood, except by the supposition (which some of their writings confirm) that they imagined a fixed and universal measure of length to exist in nature, and to have been actually obtained. At the beginning of the 16th century the Roman mile, at least the mile of 5000 feet or 1000 paces, was generally used by writers [MILE], and itinerary measures were more often written about than verified. The stadium, or eighth part of this mile, had also been introduced (into books) from the Greek system, and it was the common opinion, derived from Ptolemy, that the degree of latitude was exactly 500 stadia, or 62½ miles. This made the pace, or the 125th part of the stadium, stand forward as a proper universal measure, being the 62500th part of that which all believed the degree of latitude to be. But though this may be a probable origin of the geometrical pace, it is certain that writers did not adhere uniformly to it, so that the later metrologists have formed different notions of its length. We shall give the accounts of several modern writers.

Dr. Bernard makes the geometrical pace (which he also calls the land-surveyor's pace) to be five English feet. Greaves supposes that a pace of upwards of 69 inches was once in use in England. Ozanam makes the geometrical pace to be the same as the Roman pace. Eysenschmidt does not mention the measure at all. Paucton (who has a theory about the derivation of measures from parts of the human body) makes it only 4¼ Roman feet. Romé de L'Isle, who contends that Paucton has several times confounded the Greek Olympic foot with the Roman foot, makes it 4½ Olympic feet, that is, 4½ English feet very nearly. An old writer, Samson d'Abbeville, cited by Paucton, lays down the geometrical pace at 5 French feet, and nevertheless makes the Roman mile to contain a thousand such paces. The conclusion is, that the geometrical pace was an invention of the old writers, a needless addition to the confusion in which their accounts of ancient measures were already enveloped.

There is a pace mentioned in ecclesiastical writers called *passus ecclesiasticus*, or *dexter* (see Ducange, at the word Dextri), which Dr. Bernard, without stating any authority, makes of the same length as the English yard.

PACKFONG. [GERMAN SILVER.]

PACKING-PRESS. The hydraulic press invented by Mr. Bramah, besides being used to draw piles, trees, &c., from the ground, or to prove the strength of materials, is frequently employed to pack or compress bales of linen, cotton, and the like goods into small dimensions for the convenience of transport. A description of this machine has been given under HYDRAULIC PRESS; and it is intended here merely to notice the method employed by Mr. Barlow to determine the thickness which the cylinder should have in order that its strength may be in equilibrio with the strain to which it is subject from the pressure of the fluid within it.

Within any section of the cylinder made by a plane perpendicular to the axis, the tendency of the contiguous particles of metal to separate from one another in a direction perpendicular to a diameter passing through them, in consequence of the expansion produced by the pressure of the fluid, becomes continually less from the interior to the exterior circumference of the section, and is inversely proportional to the distances of the particles from the axis of the cylinder; and the cohesive power of the particles is, by the laws of elasticity, proportional to their separation, while the strain produced by the pressure of the fluid varies, at any part of the section, with the distance of that part from the axis. It follows that the resistance opposed at such part of a section to the momentum of the pressure is inversely proportional to the square of the distance from the axis.

Therefore r representing the radius of the interior surface of the cylinder, t the whole thickness, and x any variable distance from the interior surface towards the exterior, all in inches; then $\int \frac{r^2\,dx}{(r+x)^2}$, multiplied by 2π, and also by the force of cohesion on a square inch of the metal, will express the resistance produced by an annulus which is one inch deep in a direction parallel to the axis. That integral, for the whole thickness t, is $\frac{rt}{r+t}$; therefore f (in pounds) denoting the force of cohesion, $\frac{2\pi rtf}{r+t}$ expresses the whole resistance.

If f' (in pounds) represent the force on a square inch of the interior surface, by which the pressure of the fluid tends to strain the cylinder, $2\pi rf'$ will denote the whole strain on the same annulus; therefore, equating the strength and strain, there is obtained

$$t=\frac{rf'}{f-f'}$$

This value of t expresses the required thickness.

PÆDO-BAPTISTS (those who baptise children, from παῖς and βαπτίζω), a term used by modern theological writers, not as the designation of any particular body of Christians, but for the sake of distinguishing all those, of whatever sect, who practise infant baptism, from the body who are called Baptists. [BAPTISTS.]

PAGODA. [CHINESE ARCHITECTURE.]

PAINTER'S COLIC, called also Devonshire colic, and colic of Poitou, from its former frequency in those parts, is a peculiar and well-known variety of colic, to which lead-miners, painters, and others who use that metal are subject. The symptoms are, severe pain in the belly, with obstinate constipation and occasional vomiting, which is generally followed by partial palsy, and in violent cases by apoplexy. The palsy mostly affects the upper extremities, so that the arms hang powerless by the sides, the extensor muscles being the most impaired. Emaciation and paleness of the muscles affected are of very frequent occurrence.

"A first attack, taken under timely management, is for the most part easily made to terminate favourably. In such circumstances it rarely endures beyond eight days. But it is exceedingly apt to recur, especially if the patient return to a trade which exposes him again to the poison of lead. Sometimes the primary stage of colic is wanting, so that the wasting of the muscles and loss of power are the first symptoms." (Christison.) A peculiar livid line along the gums close to the teeth, is an invariable concomitant characteristic of lead-poisoning from the habitual exposure to it.

The principles to be observed in the treatment are, to remove the pain and constipation, and to obviate or lessen the remote effects. In first attacks it is not very difficult to effect the former object, but with every succeeding attack these symptoms are found more obstinate. Inflammation is rarely a primary symptom, but may ensue, as in other kinds of colic. Want of power in some portion of the bowel, by which it becomes distended, and excessive contraction of another portion, are the usual conditions.

By saline purgatives, such as sulphate of magnesia, sulphate of alumina and potass, or phosphate of soda in solution, followed shortly by a large dose of opium, the constipation may be removed in the milder cases. To counteract the occurrence of inflammation, calomel and opium are preferable means to bleeding, in a disease where debility is one of the usual consequences. The constipation has been known to last for a month. In such a case it was customary to give the patient three or four pounds of crude mercury, in the hope that by its mechanical properties it would force a passage. Nothing is more reprehensible, as it irritates the contracted part of the bowel, and distends yet further the enfeebled and dilated part. Most cases of constipation will yield to pills of aloes and sulphuric acid, in the proportion of one drop of strong sulphuric acid to four grains of powdered aloes. Two of these pills every four or two hours will speedily remove this state.

The paralysed arms must be supported by splints. It is however of little use to cure a first attack, if the sufferer be immediately the subject of a second, which he certainly will be without the greatest care. Should he be unable to change his employment, he must be very strict in the observance of the following rules: he should never eat without first thoroughly washing the hands and face; and never take his meals in the workshop. "Yet it is the common practice of the smelters of lead," says Dr. Percival, "and others also who live in the neighbourhood of smelting-mills, to broil mutton, beef, and pork steaks on the hot pigs of lead, by which the flesh acquires a peculiar agreeable flavour." When leaving work, a different suit of clothes should be put on, and when baths are attached to the manufactory, a complete immersion in these, after work, is advisable. The miners of Alston Moor derive great benefit from the saline mineral waters of Cartnell Holywell, to which they annually resort. Here, besides the chemical constitution of the waters being appropriate, an action on the bowels is caused, and it is observed that an open state of the bowels is always a great protection. On this account many masters keep a supply of castor oil on the premises, to which the workmen have free access. Fat and oily food is likewise a great safeguard. Sobriety is still more effective as a safeguard, for it is observed that among miners, potters, and all persons working among lead, drunkards suffer soonest and most severely. In all cases where the dust of the lead can be kept down by watering, this should be done, as it proves a very valuable means of exemption. "Wherever it is practicable, other more innocent articles should be substituted for lead, in the various manufactures where it is now used." [LEAD.]

(Christison *On Poisons;* and Thackrah *On the Effects of Arts, Trades, and Professions.*)

PAINTING is the art of representing objects by means of colour on a plane surface. In the present article it is intended, not to enter upon the question of the purpose or the limits of the art, nor to discuss its principles or practice, but merely to give a broad sketch of its history, leaving the details to be filled in by a reference to the names, in the Biographical Division of this work, of the principal painters mentioned in the course of the article.

As far as our knowledge extends the history of painting commences with Egypt, where it may be traced back to a very remote antiquity. Of the two arts, sculpture was probably the elder; and painting may at first have been chiefly exercised in connection with it: statues and rilievi being first coloured with more or less taste and skill, and the outlines and figures in sunk relief (intaglio rilevato) being carved on pillars and walls, and the enclosed space coloured to imitate the natural appearance of the objects. But during the 18th dynasty, or 1400 B.C. and downwards, the most flourishing period of the arts in Egypt, painting proper, according to the definition given at the commencement of this article, was commonly practised. Egyptian painting has been conveniently divided into three classes: mural painting; painting on mummy cases; and painting on papyrus; to which might be added the portraits on wooden panels, of which several have been found in mummy cases, and which also appear, from passages in Greek authors, to have been presented as votive offerings in the temples. The earlier painting was strictly hierarchic and symbolical; later it became somewhat freer, but always it was closely bound by conventional rules, and as much a mechanical as an intellectual art. The human form was depicted according to a definite canon, of which there is an example in a tablet in the British Museum at least 3000 years old. In all Egyptian paintings the human figure is drawn with less truth and freedom than figures of animals; but in neither is there any attempt at foreshortening. The subjects on the walls of tombs, which are most like pictures as the term is commonly understood, comprise chiefly religious or funeral ceremonies, rural occupations, fowling, banquets, and household employments. In these, little of what is called composition or grouping appears to have been attempted; the colours are bright, and unbroken by modification of tint, or light and shadow; and the artists were ignorant of perspective, the figures being placed one above another, and such objects as a rectangular fish-pond being drawn as on a ground plan, almost precisely as in the rude pictures of the ancient Mexicans. The colours used are the primitives, red, blue, and yellow; with green, black, brown, and gray. They have been shown by analysis to consist of metallic oxides, as well as of vegetable pigments. The vehicle employed with the colours was usually glue, but occasionally, though probably only at a comparatively late date, wax dissolved in naphtha was also used. The picture was sometimes covered with a varnish of glue, in order to preserve the colours from the dust or from atmospheric action, and occasionally a varnish of resin appears to have been employed for the same purpose.

From the state in which Belzoni found the great tomb of the kings of Thebes, and from an examination of various mural paintings, the method of working adopted by Egyptian painters has been ascertained with tolerable precision. After the wall was made quite smooth it was covered with an intonaco of fine lime and gypsum, which was suffered to dry, and then polished. Upon this the outline of the figures was carefully drawn, of sufficient strength to show through a thin coat of limewash which was spread over it; and upon this the colours, mixed with glue prepared from thick hides, were painted. For the paintings on mummy cases the wood was usually covered with cloth saturated with glue; on this cloth was spread a ground of gesso, and upon this the pigments, rendered opaque by an admixture of chalk, or simply mixed with glue, were laid. The portraits on tablets of cedar, sometimes found in mummy cases, are also covered with a coating of gesso, and in these portraits some approach is made to the modulation of surface by means of light and shade. The British Museum contains a great many examples of Egyptian paintings and painted hieroglyphics. Among the most interesting is a series of twelve fragments of frescoes (Nos. 169–180), painted as described above, which were brought from a tomb at Thebes, and which contain representations of the royal granaries; the taking of fowls, and of fish; foreigners bringing tribute; royal banquets and entertainments, with musicians, dancers, &c. In the First Egyptian Room at the British Museum (Case 39), are many of the implements used by Egyptian painters, including rectangular pallets, with grooves for the brushes and reed pens, and wells in which the colours were kept mixed for use; also colour boxes; mullers and slabs for grinding the colours; fragments of colours, and a brush made of the fibres of palm-leaves. (The great work of Rosellini, 'Monumenti dell' Egitto' (Tavoli Mon. Civili), contains numerous examples of Egyptian paintings: see also Wilkinson's 'Ancient Egyptians,' and 'Egyptian Antiquities,' vol. ii.)

Of Assyrian pictures, no instance has, we believe, been found. That they had "images of men portrayed on the walls" in gorgeous raiments and with bright colours we know; but these were no doubt the sculptured slabs of which Botta and Layard exhumed so many examples, and which from the traces of colour found on them, as well as from secondary evidence, we know to have been originally brilliantly painted. But that the Assyrians painted pictures even of the kind which the Egyptians painted we have no proof.

Painting in Greece.—The origin of painting, like that of most of the arts, was involved by the ancient Greeks in their legendary history. There can be little doubt that Painting like Sculpture was derived by the Greeks from Egypt. In their traditions respecting the inventors of drawing and colouring they may however have preserved some memorials of those who assisted in raising the art from its primitive rudeness and narrowness of scope. Homer, though he mentions garments elaborately embroidered or woven with figures, speaks of nothing nearer akin to painting than the colouring of the ships or the staining of ivory by a Carian woman. The origin of the art in its simplest form of the outline of a shadow, is ascribed to Corinth or Sicyon; but the story of its supposed inventor, as recorded by Pliny, is evidently deserving of little attention. Cleanthes of Corinth is said to have made the first outline; Ardices, of the same city, and Telephanes of Sicyon, to have introduced some lines within the figure; and Cleophantus to have coloured it with a single colour, and thus produced *monochromata*. Corinth was the great centre of the ceramic art, and these frequent references to Corinthian painters point with sufficient distinctness to the early connection between the potter's art and painting. The legend of Cleophantus, or Eucheir and Eugrammus, having accompanied Demaratus from Corinth to Italy (Olymp. 30, B.C. 657), probably points to the early connection of Greek and Italian art, or to the taste for the former which existed in Etruria and the neighbouring countries, as is sufficiently attested by the innumerable vases with Greek stories and Greek inscriptions now found in Italy. The grotesqueness and clumsiness of the figures on the earlier vases, and their progressive improvement, show how little ground there is for the notion that the proportions of the human figure in early Greek art were fixed by some type derived from Egypt or elsewhere, instead of gradually developing themselves as the culture of the race advanced.

The very curious paintings on the walls of the Etruscan tombs should here be mentioned; and Pliny speaks of ancient works existing in his time in a temple at Ardea, as well as at Cære and Lanuvium.

Between the 50th and 80th Olympiad (from 580 to 460 B.C.) painting advanced considerably in Greece.

Historical pictures of very early events are recorded, one indeed by Bularchus, in the reign of Candaules, who died Ol. 16. 1, B.C. 716. Cimon of Cleonæ invented *catagrapha*, that is, figures seen obliquely from above or below, and thus applied the rules of perspective. The peculiarities of drawing of this early period are best learned from the study of the ancient vases; the forms and protuberance of the muscles are exaggerated, and the positions strained and whimsical.

Polygnotus of Thasos, who probably settled at Athens about Ol. 79. 2 (B.C. 463), was the first painter of great excellence, and the founder of what may be called the Athenian school. Aristotle ('Poet.,' vi. calls him *ἀγαθὸς ἠθογράφος*, "successful in his expression of character;" and speaks of him as painting men better than they are. The characteristic of his style was elevation and largeness of design, with purity of form and force of expression. Pliny speaks of him as having abandoned the old stiffness, and having given movement to the features. His transparent drapery is also mentioned. Pausanias (x., 25-31) describes his pictures in the Lesche at Delphi—the Capture of Troy, the Departure of the Greeks, and Descent of Ulysses to the Shades. In the Pœcile at Athens his works stood by the side of the Battle of Marathon by Panænus, the nephew or brother of Phidias, and of the Combat between the Athenians and the Amazons by Micon. This latter artist, together with Onatas of Ægina and Dionysius of Colophon, were the most celebrated contemporaries of Polygnotus.

The principles of light and shade were investigated by Apollodorus of Athens about the 94 Ol. (B.C. 404). To the school of Athens succeeded what may be termed that of Ionia, in which illusion seems to have been more aimed at. This we may infer from the well-known story of the grapes of Zeuxis and the linen cloth of Parrhasius. Zeuxis, with whom begins the second epoch of the more advanced art, was of Heraclea, and flourished about Ol. 94. (B.C. 404). His excellence seems to have been equally conspicuous in female beauty (as the Helen of Crotona), and the sublimity of Zeus and his attendant gods; whilst in technical skill he surpassed all his predecessors.

Parrhasius was of Ephesus, and he is no less celebrated for the roundness and relief of his figures than for their exquisite form and expression. His contemporary Timanthes overcame him in one of those contests between painters which were not unfrequent in Greece, and which are said to have been first instituted at Delphi in the time of Panænus. Among the ancient paintings from Pompeii is one of the same subject (the sacrifice of Iphigenia) as that of Timanthes, mentioned in Pliny, and in which the grief of the father is represented in the same way by the concealment of the face.

Another school arose at Sicyon, in which the most celebrated names were—Euphranor of Corinth (Ol. 104-110, B.C. 364-340), Pausias of Sicyon (Ol. 103, B.C. 368), Aristeides of Thebes (Ol. 102-112, B.C. 372-332), and Pamphilus of Amphipolis (Ol. 97-107, B.C. 392-352). The first of these, a sculptor as well as a painter, was laborious and consistently excellent in all that he undertook. Aristeides was remarkable for his expression of passion; Pausias practised encaustic painting with great success, having acquired the art from Pamphilus. Pausias was noted for his children and lighter subjects, and first decorated roofs and arches with figures. Pamphilus succeeded in establishing a knowledge of the rudiments of drawing as part of a liberal education. He was moreover the teacher of Apelles, who united the softness and colouring of Ionia with the science of the Sicyonian school. His excellence in female beauty was attested by the Aphrodite Anadyomene at Cos; his power in sublime subjects and his technical skill, by the Alexander wielding the Thunder at Ephesus. The liberality of Apelles first brought into notice a rival of his fame, Protogenes of Rhodes, or rather of Caunus in Caria. This artist excelled in a laborious study of nature, and Apelles declared that his own superiority over Protogenes consisted in his knowing when to leave off. They both executed numerous portraits, and Apelles was honoured with the exclusive privilege of painting Alexander the Great. Nicomachus probably preceded Apelles; he seems to have rivalled Luca Giordano in quickness of execution. Nicias of Athens, Theon of Samos, and Melanthius were contemporaries of Alexander. The first of the three was excellent in light and shade, and painted battles and historical subjects on a large scale.

From the death of Alexander, and as a consequence partly of the political disturbances which followed, the decline of painting was continuous. Painters indeed met with ample encouragement, but they worked for private rather than public enjoyment, and their attention was directed mainly to a lower class of art,—to that which could be produced rapidly for the glorification of kings and rulers or the gratification of the affluent. Instead of representations of the gods, and of the great events of epic verse or Hellenic history, works of the class we now call *genre*, low and domestic subjects (rhypography), and even pornography (obscene pictures), were eagerly sought. These last became more general as the art fell lower, and painters sought popularity by novelty of style and familiarity of subject, or gain by making their art the creature of luxury and sensuality; but even Parrhasius was noted for pictures of a libidinous character. Vase-painting gradually died out in this period; but, on the other hand, mosaic was introduced, and acquired great popularity, and Greek musivarii were in much request for the preparation of mosaics for Rome. Landscape-painting was likewise introduced late, and never flourished among the Greeks, though the art was cultivated by Greek painters for the gratification of their Roman employers.

Some time before the spoliation of Greece, Greek painters had migrated to Rome and found employment there. But as the plunder of the Grecian cities by the Roman generals went on, the passion for works of art among the Romans seemed to increase; and as the love of art, or the power of rewarding its professors, declined in Greece, Grecian artists betook themselves in constantly increasing numbers to the Roman capital, so that about the end of the republic Rome was spoken of as full of them. Many migrated also to Egypt and Asia, and elsewhere, until such Grecian painters as were left were to be sought anywhere rather than in their native country.

Instead of tracing further the decay of the art, it may be well to speak briefly of the kinds of painting practised and the materials employed whilst Greek painting was in its maturity. The earliest occupation of the painter in Greece, as in Egypt, seems to have been in colouring sculpture; and from the gaudy daubing of the primitive wooden figures of the gods, down to the refined tinting of the most exquisite statues of the greatest of the Greek sculptors, this was always regarded as a branch of the painter's art. Praxiteles himself, according to the well-known story, when asked which of all his statues he preferred, replied, "That in which Nicias had a hand"—Nicias being one of the most eminent painters of his time. What this *circumlitio*, as Pliny terms the statue-painting of Nicias, really was, will be considered under another head. [POLYCHROMY.] Another of the branches of the art for which the painters were always famous—that, namely, of vase-painting—will also be noticed more conveniently elsewhere.

The pictures ordinarily painted by the Greeks up to an advanced stage of the art, appear to have been almost exclusively easel pictures executed in tempera. They were painted chiefly on wooden panels, which had probably been prepared with a gesso ground; but paintings were also executed on stone, plaster, parchment, and, though not till a late period, on canvas. Glue or size, white of eggs, and gum were the vehicles commonly used in mixing and applying the colours. Wax was also used, boiled with mastich or mixed with a mineral alkali, so as to be employed as a water-colour medium. The application of wax by means of fire, or encaustic painting, was of later introduction; for though practised by Pausias, who is said to have learned the method from Pamphilus, it was not generally adopted till about the time of Alexander. [ENCAUSTIC PAINTING.] Fresco-painting was also of late introduction, but in the later stages of the art was, either alone or in conjunction with encaustic, much employed in paintings on walls and ceilings, and generally in works of a decorative character. Vitruvius says that the Greeks attained such skill in the preparation of fresco walls, that, in his time, people were accustomed to cut slabs from them, which could be packed up and carried to any distance. The finer fresco-paintings, according to Vitruvius and Pliny, were, when finished, covered with an encaustic varnish, which heightened and preserved the colours. Oil as a vehicle appears to have been unknown.

The four colours which were the basis of the colouring of the Greeks down to the time of Apelles were—1, white, Melian earth, or, more rarely, cerussa, white lead; 2, red, rubrica from Cappadocia, called sinopis; 3, yellow, sil, *ὤχρα*, from the Attic silver-mines; 4, blacks (probably including blues), atramenta, *μέλαν*, from burnt plants or ivory. These were the "*colores austeri*," to which were afterwards added the brighter and more expensive colours, "floridi," which were usually furnished to the painter by his employer; but the palette appears always to have been restricted to a comparatively few well-chosen and carefully-prepared colours. This restriction to a few colours was one of the things which satisfied Sir Joshua Reynolds—an indisputable authority in a question of colour—of the superiority of the Greeks as colourists. Another, was their use of atramentum. "What disposes me," he wrote (Note xxxvii. to Du Fresnoy), "to think higher of their colouring than any remains of ancient painting will warrant, is the account which Pliny gives of the mode of operation used by Apelles; that over his finished picture he spread a transparent liquid like ink, of which the effect was to give brilliancy, and at the same time to lower the too great glare of the colour: 'Quod absoluta opera atramento illinebat ita tenui, ut id ipsum repercussu claritates colorum excitaret;—et cum ratione magnâ, ne colorum claritas oculorum aciem offenderet.' This passage," he adds, "though it may possibly perplex the critics, is a true and an artist-like description of the effect of glazing or scumbling, such as was practised by Titian and the rest of the Venetian painters. This custom, or mode of operation, implies at least a true taste of that in which the excellence of colouring consists, which does not proceed from fine colours, but true colours,—from breaking down these fine colours, which would appear too raw, to a deep-toned brightness. Perhaps the manner in which Correggio practised the art of glazing was still more like that of Apelles, which was only perceptible to those who looked close at the picture, '*ad manum intuenti demùm appareret*;' whereas in Titian, and still more in Bassan and others, his imitators, it was apparent on the slightest inspection."

Greek painting at its best, there cannot be much doubt, was only a little, if at all, inferior to the sculpture of the same period. The men who saw and appreciated the one admired equally the other. The paintings, equally with the statues, were praised for their grandeur of thought and expression, for their nobleness of design, and accuracy of imitation. Foreshortening and perspective, essential qualities in a picture, were understood and practised. So also were the laws of light and shade, though that disposition of light and shadow in masses, which modern writers call *chiaroscuro*, was probably unknown. Colour, as we have seen, was studied in its subtlest refinements. Whether, as Sir Joshua Reynolds expressed his assurance, "if what has happened in the case of sculpture, had likewise happened in regard to their paintings, and we had the good fortune to possess what the ancients themselves esteemed their master-pieces, we should find their figures as correctly drawn as the 'Laocoon,' and probably coloured like Titian," we cannot venture to say. We have none of their master-pieces; but the works brought to light since Reynolds wrote, though at best only such as were executed in the decline of art for decorating the provincial residences of affluent foreign patrons, suffice fully to justify his sanguine anticipations. The finest ancient picture yet discovered is that known as 'The Battle of Issus,' found at Pompeii in 1831, and now in the Museo Borbonico at Naples. It displays great skill in design, knowledge of foreshortening and perspective, and immense vigour of expression, though the execution is inferior to the conception. This is a mosaic, but was probably a copy in imitation of some celebrated painting of an earlier date, as the chief extant remains of Græco-Roman sculpture are known to be copies of famous old statues. Another mosaic of admirable design is that of the Choragus engraved under Mosaic. The finest extant painting of Græco-Roman date is that known as the 'Abdobrandini Marriage,' found originally on the Esquiline Mount, and now in the Vatican—a fresco-painting executed with great freedom, and excellent both in composition and colour. Equally remarkable in their way are the paintings of 'Achilles Discovered by Ulysses,' found in the House of Castor and Pollux at Pompeii (Zahn, ii., pl. 23); an 'Achilles in a Quadriga,' painted in monochrome; and a 'Dirce attached to the Bull,' found in the House of the Grand-Duke at Pompeii in 1833, and, like the preceding, engraved in Zahn. Many others might be mentioned which, if regarded as they ought to be, as late and feeble imitations, would attest sufficiently the high character of Greek painting when in its more flourishing condition. (See engravings in Müller, 'Denkmaler der Alten Kunst;' D'Agincourt, 'Hist. de l'Art par ses Monumens;' Mazois, 'Pompèi,' tom. iv.; the 'Mus. Borbonico;' and Zahn, 'Die Schönsten Ornamente und merkwürdigsten Gemälde aus Pompeii, Herculaneum, und Stabiae.')

Painting in Rome.—The Romans had no independent school of painting. We have spoken of the early connection of Greece with Italy and with Magna-Græcia, and the later migrations of Greek painters into Rome. It was by these mainly, if not exclusively, that the pictures painted in Rome and the provinces were executed, and of which examples remain in the frescoes and mosaics exhumed at Rome, Pompeii, and elsewhere. Pliny, however, speaks of certain Romans who cultivated painting long before Greek pictures were brought to Rome. C. Fabius Pictor is said to have derived his name from decorating the temple of Health (A.U.C. 450, B.C. 304). The poet Pacuvius (B.C. 219-140) was an artist. The victory of L. Scipio over Antiochus (B.C. 190) was recorded by a picture in the Capitol, as that of M. Valerius Messala over Hiero had been by an historical painting in the Curia Hostilia (B.C. 264). The first foreign picture publicly exhibited at Rome was after the sack of Corinth by Mummius (B.C. 146), an event which brought many of the finest works of art to the conquering city, however little the victors were qualified to appreciate their real worth. At a later period we hear of Arellius, Amulius, Accius, Priscus, and Ludius, of whom the last, in the time of Augustus, painted landscapes, garden scenes, and buildings on the walls of rooms, such as we see in the ruins of Pompeii or the remains of the palace of Nero. Cæsar purchased the 'Ajax' and the 'Medea' of Timomachus for 80 talents, and at his time a school of some eminence existed at Cyzicus. The forced bloom of art which characterises the age of Hadrian implied a momentary revival of painting, and Aetion (of whom Lucian speaks so highly) must probably be reckoned as his contemporary.

When Pliny wrote (about A.D. 75), painting was already an expiring art (*artis morientis*); the most splendid colours, he says were used, but nothing worth looking at was produced. Mural painting was chiefly practised, the painting being executed in a light rapid manner, and the subjects such as would surprise the spectator by some trick of art. Grotesques and fantastic architectural and landscape designs formed the decorations of apartments; or gay and brilliantly coloured mythological subjects mingled with grotesque borders and garlands of flowers on roofs and walls. The best pictures were those which aimed at the reproduction of the more celebrated works of earlier artists. We have the names of many painters of this age of decrepitude, but they are names only; the art was felt to be so fallen that the artists themselves were despised, and painting came at length to be the occupation of slaves and men of slavish minds. The last embers of native power were extinguished amidst the turmoils of civil dissensions, and the inroads of foreign barbarians.

For further information on the painting of the ancients, see Müller, 'Handbuch der Archäologie der Kunst;' Bottiger, 'Ideen zur Archäologie der Malerei;' Raoul-Rochette, 'Recherches sur l'Emploi de la Peinture;' and 'Peintures Antiques;' Junius, 'de Picturâ Veterum;' and Sillig's 'Catalogus Artificum;' Thiersch, 'Ueber die Epochen der bildenden Kunst unter den Griechen;' and Mr. Wornum's article, 'Pictura,' in Smith's 'Dictionary of Greek and Roman Antiquities,' with the authorities there cited.

Mediæval painting.—From the ashes of this extinct ancient art arose a new form, which our zealous modern mediævalists have distinguished with the name of Christian art. But as it was chiefly Christian inasmuch as it was the art of the priest and the cloister, it might with equal justice have been designated Monastic, or Ecclesiastical Art, if it had been intended to mark its origin or application; while from its being nearly coincident in duration with the period known as the middle ages, its date is more specifically indicated by the older phrase, Mediæval Art, and its source, as far as painting is concerned, by that of Romanesque or Byzantine. As, however, the term Christian Art has found pretty general acceptance, it may without inconvenience be employed indifferently with either of the others.

In the first centuries, however, Christianity was too uniformly oppressed to require the blandishments of art; and the Judaic notions of a large proportion of its professors would probably have prevented them from calling in the assistance of painting for the decoration of their places of worship, or for recording the events and miracles of their faith, even had they been at liberty to do so. The earliest examples of art applied to Christian purposes occur in the catacombs of Rome [Catacombs], where, on opening those vast subterraneous vaults in the early part of the 17th century, the sides and roofs were seen to be almost covered with paintings and inscriptions; and numerous sarcophagi bore similar examples of the sculptor's chisel. The effects of air and damp, and the smoke of numberless torches have combined to obliterate the paintings left *in situ*, but a large proportion of them will be found engraved as well as described in the works of Aringhi, Bosio, Bottari, and Bunsen, on Subterranean Rome, in D'Agincourt's 'Hist. de l'Art,' and Maitland's 'Church in the Catacombs;' while as many as were removable of the painting themselves, and carefully executed copies of others, have been collected and placed in the Vatican and in the palace of St. John Lateran at Rome. As might well be supposed from their place, no less than their age, these works are extremely rude and inartistic; and at times they exhibit a rather incongruous adaptation of heathen symbols and personages; but on the other hand, some excellent critics discover in them much grandeur of arrangement, and a "peculiar solemnity and dignity of style." (Kugler, 'Handbook of Painting: Italy.')

From the removal of the seat of empire to Constantinople, Rome ceased to be even nominally the centre of the arts, though that there were undoubtedly native painters in Rome, as well as in other parts of Italy, down to the revival of painting in the 13th century, is certain, from the remains still extant in many cities of Italy; from the illuminations in manuscripts [Miniature]; from the Mosaics [Mosaics]; from the painted series of popes in the Basilica of St. Paolo, commenced in the 5th century by order of St. Leo, and from other evidence. For above two centuries Byzantine art differed in no essential respect from that of Rome. It was not till about the reign of Justinian that Byzantine art arrived at its full development; but thenceforward, Byzantium remained, till the great revival of painting in Italy in the 13th century, the grand central school which supplied artists, works of art, and the laws by which they were judged, to all parts of Europe. But art itself was now at almost its lowest ebb. The works produced were chiefly for churches or religious purposes. All traces of the traditions of the ancient schools seem to have been lost, though some desire to imitate ancient forms was retained. Something of the oriental love of gold and bright colours appears to have been engrafted on the western modes of working. The figures were ill-drawn, rigid in character, ungainly in position, long and meagre in their proportions, and devoid of all reality. The colours, though bright, were raw and crude, and commonly painted on a gold background. Enormous mosaics or frescoes of the St. Saviour, and figures of the saints, of the most strictly conventional type, were placed in all the churches. Individuality of style was entirely ignored. The same characteristics occur in Byzantine paintings, mosaics, and miniatures wherever found. And the same characteristics have distinguished the school down to the present day: for in Greece and Russia, and wherever in fact the Greek church exists, religious pictures of precisely the same type have continued to be manufactured. M. Didron ('Manuel d'Iconographie,' p. ix. &c.), on visiting the monastery of Mount Athos, now the principal manufactory for pictures for the Greek churches throughout the world, saw painters engaged in the execution of pictures according to a strict and singularly minute code of laws, ''Ερμηνεία τῆς Ζωγραφικῆς' ('Guide for Painting'), a copy of which he with some difficulty procured, and of which translations have been published in French by M. Durand, and in German by Dr. Schäfer ('Das Handbuch der Malerei vom Berge Athos). To such mechanical perfection had the painters, whom M. Didron saw at work, attained—each man taking his own part of the picture—that he actually witnessed the Monk Joasph and five assistants paint in fresco entirely from memory, without cartoons, tracings, or any other mechanical aid, a picture of Christ and the Eleven Apostles, all the size of life, in the space of an hour! This swiftness and certainty of execution are the result of the training and experience of centuries directed upon unchanged repetitions; but we have here only an exaggeration of mediæval Byzantine art with all its soulless traditional design and absence of thought, imagination, and individuality. The art of Byzantium is best seen in Miniatures and Mosaics, to which headings we refer the reader for further information.

Revival of Painting in Italy.—The Ostrogoth dominion was not unfavourable to art; at least there is a studied affectation of classical knowledge in Cassiodorus, and the mutilators of ancient statues are denounced as criminals. The Lombards could have brought no art with them, and were unlikely to appreciate what they found. The most remarkable monument of their time is the large MS. of the Bible from Mont Amiata, still preserved in the Laurentian Library at Florence; but others scarcely less beautiful are not uncommon. [Miniature.] The union of the Church with the Frank Empire gave the popes greater leisure and means, and Rome became once more a capital.

It is probable that the conquest of Constantinople by the Latins in 1204 supplied to the Italians some of that technical skill which the wild conflicts of their own parties at home had contributed to obliterate. Numerous Greek artists settled in the cities of Italy, and a semi-Byzantine style is visible in the painting as well as in the architecture of Venice, Pisa, and Siena.

But native painters of remarkable talent arose, first perhaps in the last named city, who soon cast off the trammels of Byzantine tradition, and painting once more rose to the dignity of a fine art, assuming a position such as it could only have previously held when the arts of ancient Greece were in their most flourishing state. We shall be able to trace the history of painting in Italy most conveniently by noticing in succession the principal Italian schools of painting. (The term school of painting is explained under Bolognese School of Painting.)

Tuscan School of Painting.—This is frequently called the *Florentine School*, and is divided into several epochs, the first of which is termed the old Florentine; but the school of Florence was not the school of Tuscany until after the time of Michel Angelo. In the earliest period of painting in Tuscany the principal painters were of Pisa and Siena, and there is characteristically no essential difference between their works and those of the early painters of Umbria of the same period. Sienese critics have discovered a distinct school in the works of the old masters of Siena, but it would be difficult to show any other distinction than a mere difference of local origin.

Some artists of Siena and Florence, of the early part of the 13th century, are the oldest painters of Tuscany that are known. There were painters in Pisa before this time, in the 11th century, but they were Greeks from Constantinople: and there are paintings extant in Tuscany which are said to be of the same period, but they are probably the production of Greek artists. In the church della Trinità at Florence there is a picture of Christ painted upon canvas, and glued upon a wooden cross, which is probably of the 10th century; it was done before 1003: and in the church of San Miniato al Monte near Florence there is a Greek painting of San Miniato Martire, of the 11th century. ('Etruria Pittrice.')

The first considerable efforts towards the revival of painting were made by the Tuscans, and the Tuscan painters throughout have done much towards its improvement and perfection in later periods. The following masters are among the most celebrated in the history of painting, both for their works and for the great changes they effected in the prevailing styles of their respective periods: Giotto di Bondone of Vespignano (b. 1276, d. 1336); Tommaso Guidi, of San Giovanni, called Masaccio (b. 1401 or 1402, d. 1443); Lionardi, of Vinci (b. 1452, d. 1519); Michel Angelo Buonaroti, of Castell' Caprese, in the diocese of Arezzo (b. 1474, d. 1563); Ludovico Cardi, of Cigoli (b. 1559, d. 1613); and Pietro Barrettini, of Cortona (b. 1596, d. 1669). All these painters, through the striking characteristics of their respective styles, made epochs in the history of painting in Tuscany.

The oldest Tuscan artists whose names are known are Niccola and Giunta of Pisa. [Pisano, in Biog. Div.] Niccola Pisano, or of Pisa, was a sculptor, and the first restorer of design from the excessive rigidity of the Byzantine forms; he endeavoured to imitate the style of a bas-relief upon an ancient sarcophagus at Pisa: he lived at the beginning of the 13th century. Giunta Pisano is the earliest Tuscan painter to whom extant works have been assigned: he is said to have learnt painting of some Greeks who were at Pisa about the year 1210. In 1230 he was employed in the church degli Angeli at Assisi: there are a crucifixion and some other figures painted upon a wooden cross, the colours of which are mixed in some medium not affected by water. The drawing is careful, but very dry, and the fingers are extremely long—faults, as Lanzi has observed, not of the men, but of the times. The expression in the heads, however, is good, the draperies are well arranged and the colouring, though brown, is laid on with a strong impasto. Some frescoes by Giunta are in the upper church of San Francesco at Assisi.

Contemporary with Giunta of Pisa, were Guido of Siena and Buonaventura Berlinghieri of Lucca. The former was illuminator and painter: a Madonna in the Malevolti chapel in the church of San Domenico at Siena, engraved in Lastri's 'Etruria Pittrice,' has very great merit for its period. Siena had many other painters about this time, and they were even constituted as a civil body in 1250. Ugolino of Siena, says Vasari, painted pictures and chapels in every part of Italy; he died at an advanced age in 1339. Buonaventura Berlinghieri of Lucca painted in 1236; there was also a Diodato of Lucca, who was living in 1288.

A very superior painter to those already mentioned, and one who added also much to the practical technic of painting, was Margaritone of Arezzo, an older painter than Cimabue. At the church of Santa Croce, at Florence, there is a crucifixion by Margaritone, which is placed near one by Cimabue; and although Margaritone's is less finished in execution than Cimabue's, the difference is not so great that the title of painter should be denied to the former if given to the latter. The portrait or picture of San Francesco di Assisi in the church of Sargiano, near Arezzo, dressed in the habit of a monk, with all the faults of the time, has a grand expression, and is a very remarkable production; it is marked Margarit' de Aretio *pingebat*: an inscription which probably indicates a Greek source of instruction, directly or indirectly.

The earliest painter in Florence was apparently Maestro Bartolomeo, who painted in 1236. An Annunciation, which he painted in the church de' Servi, has been attributed to Cavallini, the scholar of Giotto. Another predecessor of Cimabue was Andrea Tafi, born in 1213; he was the scholar of Apollonius, a Greek, whom he assisted in some mosaics in San Giovanni, at Florence. Vasari terms Tafi the first restorer of mosaic in Tuscany: he was also a painter.

A painter of somewhat more merit and much more fame than any of the preceding, was Giovanni Cimabue, born at Florence in 1240, through the partiality of Vasari, or his neglect of research, commonly called the father of modern painting. He was architect and painter; he greatly improved the proportions of the human figure in design; inspired his figures with more life than his predecessors; and excelled them in grace of execution and in richness of colouring: his works are, notwithstanding, strictly of the Byzantine style. Cimabue is said by some to have learned painting of Giunta Pisano, whom he assisted in his frescoes at Assisi, in 1253, in his thirteenth year; Vasari says that he learned of some Greeks who were employed to decorate the church of Santa Maria Novella at Florence. One of his earliest and most remarkable pictures is the Colossal Madonna, now in the Academy at Florence, formerly in the church of Santa Trinità; but his greatest works are those in the upper church of San Francesco at Assisi. Cimabue excelled chiefly in male heads, to which he has sometimes given a truth and grandeur of expression that have never been much surpassed. Contemporary with Cimabue, but somewhat younger, was Ducio di Buoninsegna of Siena, famous in his time: he painted great works in the cathedral of that place, which are in part still extant: also a remarkable altar-piece for the same church, which is still preserved there; it was painted in 1308 and 1311, and when completed was carried in procession to the cathedral. It was painted on both sides, but is now cut into two. One side, the former front, is a Madonna and infant Christ, surrounded by angels; on the other side, or former back, there is a series of small pictures illustrating the history of the Passion, all containing many figures, executed with surprising industry, skill, and judgment, when compared with the majority of the works of his contemporaries.

Gaddo Gaddi of Florence, born in 1239, was also one of the most distingushed artists of this period. He was celebrated for his works in mosaic, of which there are still specimens in the cathedrals of Florence and of Pisa. He worked also at Rome, but the great mosaics of St. John Lateran and in Santa Maria Maggiore are the work of Mino da Turrita, an earlier master, and the most celebrated of his time. The mosaics of the tribune of San Giovanni at Florence were executed by Turrita, who finished them in 1225.

That of discovering and cultivating the abilities of Giotto was not one of the least services of Cimabue. [Giotto, in Biog. Div.] Giotto surpassed all his predecessors, and he added as much to the art of his master Cimabue as Cimabue had added to that of the Greeks. In the mature works of Giotto there are no traces of the Byzantine style: they made an epoch in painting; and from his time Florence dates its preponderance in the history of Tuscan art. If Cimabue, says Lanzi, may be termed the Michel Angelo of his age, Giotto may be termed its Raffaelle. Great as was the fame of Cimabue, says Dante, it was rendered obscure by that of Giotto. Dante and Giotto were friends, and the great poet celebrated the painter in some well known lines ('Purgatorio,' xi. 32).

Giotto was painter in history, miniature, portrait, and in mosaic; also a sculptor and an architect: the celebrated Campanile of Florence is his work. He painted in many cities of Italy, but his chief works are those in the lower and upper churches of San Francesco at Assisi. In these paintings there are heads worthy in expression of the greatest masters that have succeeded him; yet, notwithstanding his great merits, his design is extremely hard and Gothic, especially in his large figures: he paid also little attention to perspective or to chiaroscuro; and although he brought painting far from its infancy, he still left it upon the whole as far from its maturity.

The scholars and imitators of Giotto were very numerous: the principal of them were Stefano Fiorentino, Tommaso di Stefano, called Giottino, and Taddeo Gaddi, the son of Gaddo Gaddi. These painters worked in the same style as Giotto, sometimes inferior and sometimes superior in execution. Stefano was called the ape of nature, "Scimia della Natura." Taddeo Gaddi, says Vasari, excelled Giotto in colouring and in tone: his principal works were painted in the church of Santa Croce; and in the chapel Degli Spagnuoli, in the church of Santa Maria Novella. The pictures of the three saints seated, in this chapel, are magnificent in the character of the heads and in the style of the draperies: they represent San Dionysio Areopagita, San Pietro Lombardo, and San Severino Boezio: they are engraved in Lastri's 'Etruria Pittrica.' Contemporary with Giotto was Buonamico di Cristofano, called Buffalmacco, the scholar of Andrea Tafi; and Bernardo and Andrea Orcagna, who painted together a heaven and a hell in the Struzzi chapel in the church of Santa Maria Novella; and in the Campo Santo at Pisa, Andrea painted a Last Judgment, and Bernardo a Hell. In the church of Santa Croce also Andrea painted similar scenes: amongst the blessed he placed his friends, and amongst the damned his enemies. The best preserved works of Buffalmacco are at the Campo Santo at Pisa.

Two celebrated scholars of Andrea Orcagna were Bernardo Nello of Pisa and Francesco Traini of Florence: of the latter there is a celebrated picture of Thomas Aquinas at Santa Caterina at Pisa.

Contemporary also with Giotto was the famous Simone Memmi di Martino of Siena, celebrated by Petrarch in two of his sonnets for a portrait of Laura. Simone was born about 1284, and after distinguishing himself by many works in various cities in Italy, he went to Avignon, where he died in 1344. He excelled in composition and in invention. Vasari speaks very highly of his great works in the chapel Degli Spaguoli, in the church of Santa Maria Novella at Florence, which was painted in 1332. Christ going to Calvary, which is one of the paintings of this chapel, is a work of great merit in expression, in composition, and in design. (Lastri, 'Etruria Pittrice.') There is in the Ambrosian Library at Milan, a MS. of Virgil with the commentary of Servius, which belonged to Petrarch; and on the frontispiece is a miniature of Virgil writing, with various characteristic accessories, by Memmi: it is supposed to have been painted for Petrarch, and that the poet wrote the following lines attached to it:—

"Mantua Virgilium qui talia carmina finxit;
Sena tulit Simonem digito qui talia pinxit."

Shortly after the death of Giotto, in 1336, painters commenced to be extremely numerous in Tuscany. In the year 1349 the painters of Florence formed themselves into a society under the name of Compagnia di San Luca (Company of St. Luke). This society was not however composed exclusively of painters: it contained various artists in metal and in wood, in whose business ornamental design was in any way concerned. A similar institution, but on a greater and more permanent plan, was established at Siena in 1355.

Other distinguished painters of this period were—at Siena, Lippo Memmi, Cecco di Martino, Ambrogio Lorenzetti, and Bernardo or Berna da Siena. At Florence were Giovanni and Angelo Gaddi, the sons of Taddeo Gaddi. Angelo Gaddi was an excellent colourist; but he was content to imitate the works of Giotto and of his father. His scholar Cennino Cennini was also a good colourist. The following also are deserving of mention: Starnina, Dello Fiorentino, Jacopo di Casentino, Spinello Aretino and his son Pari Spinelli, Lorenzo di Bicci and his son Neri, also Giovanni di Niccolo of Pisa, who all painted more or less in the style of Giotto, as did likewise all the artists of Tuscany, until a better taste was spread by the works of Masaccio.

In the 15th century, when the Medici established themselves as the rulers of Florence, and that city gradually extended its power over the neighbouring territories, and became the capital of Tuscany in matters of art as well as of state, the arts were in a manner rendered dependent upon the caprices or tastes of its princes; and as the Florentine artists, through extended patronage, gradually evinced more activity, and acquired as a body a greater importance, those of Siena and Pisa proportionably declined in both respects. The improvements made in painting at this period were very great, and one of the most essential was the commencement of a proper application of perspective: the chief promoters of this science were Pietro della Francesca and Paolo Uccello; the latter comparatively neglected every other department of painting for the study of perspective. There is in the first cloister of Santa Maria Novella a picture of the Drunkenness of Noah, by Uccello, in which he has displayed his ability in this respect: Noah is violently and well foreshortened. Another department of painting which had been neglected by the school of Giotto was chiaroscuro. This was first attempted with success by Masolino da Paincale, who executed some excellent works, for the period, in the chapel of San Pietro in the church del Carmine. Masolino is also not less distinguished for having been the master of the celebrated Masaccio, who, if any individual is entitled to this distinction, can alone be styled the father of modern painting.

That many of the painters however who preceded Masaccio had great ability, even for any period, is certain; and it is also certain that they had recourse to the study of nature—a fact which proves that the mere study of nature, without the knowledge of what to select for imitation, will not lead to the production of fine forms. And although beautiful forms have been produced by the earlier painters, it is the accident of the model, and not the result of choice; for we sometimes find the finest parts associated with others so inferior, that from their juxtaposition the whole has an appearance of deformity, which arises both from the inequality in individual models, and from the painter's occasionally trusting his own knowledge and occasionally having recourse to the model. This imperfection could only be avoided by the adoption of a standard of form, which should preserve a unity of style in every degree—a standard which, experience has shown us, it would require centuries to attain simply by the study of nature, because of the infinite varieties of form met with in individuals. This standard however already existed in the antique, and it required only the master-mind to appropriate it; and to have been the first to do this efficiently constitutes the great merit of Tommaso Guidi, commonly called Masaccio, on account of the slovenliness of his personal appearance. Masaccio introduced a style of composition and design which until the appearance of Da Vinci and Michel Angelo experienced no material change. Da Vinci and Fra Bartolomeo enlarged upon Masaccio's style. Michel Angelo invented a style of his own, and he outlived it. The style of Masaccio, however, expanded to its utmost, still lived in the works of Raffaelle and the principal painters of the Roman school. Yet the great improvement in design which was accomplished in the works of Masaccio was not entirely his own merit; for Ghiberti and Donatello had made great advancement in sculpture; and Gentile da Fabriano and Vittore Pisanello, with whom Masaccio became acquainted in Rome, had made great improvements upon the Giottesque school in painting. Masaccio's greatest works are in the Brancacci chapel in the church of Santa Maria del Carmine at Florence: they have been engraved by Lasinio and others. Masaccio died before the completion of these works, in 1443, in his forty-first or forty-second year, not without suspicion of having been poisoned. Many of his works have perished. His most able contemporaries and followers were Fra Giovanni da Fiesole, Benozzo Gozzoli, and Fra Filippo Lippi, the best painter of his time; he completed the works of Masaccio in the Brancacci chapel: he died in 1469. There are in his works much of that mellowness of colouring and harmony of light and shade which characterise the works of Fra Bartolomeo and Leonardo da Vinci. In the gallery of the Academy at Florence there are some beautiful specimens of the works of Lippi.

Other painters of great ability of this period, both in oil and in fresco, were Andrea del Castagno, called the infamous; Sandro Botticelli, Filippino Lippi, Raffaellino del Garbo, Domenico del Ghirlandajo, Cosimo Roselli, Piero di Cosimo, Antonio Pollaiuoli, the first Italian painter who studied the dead subject for the purposes of design; Andrea Verocchio, and Luca Signorelli of Cortona. There were also many others of merit of this school at about the end of the 15th century, but they followed only in the steps of others.

The works of Lionardo da Vinci, and the painters who imitated or adopted the chief characteristics of his style, constituted another epoch in the history of painting; but their influence was not confined to Florence or to Tuscany; it was greater in Milan and in Lombardy than in Florence. The fulness however and vigour of design which distinguish the works of Fra Bartolomeo, and even Michel Angelo, characterise in an equal though somewhat different degree also the works of Da Vinci, and are combined with an exquisite finish and harmony of tone which are peculiar to himself. Lionardo was born at Vinci in 1452, and learnt painting of Andrea Verocchio, who, upon seeing the superiority of his scholar, forsook that art for statuary. Lionardo was painter, sculptor, architect, engineer, mathematician, writer, musician, and poet; he is however chiefly known as a painter. Historians have divided his career into four periods; he painted at first in the manner of Verocchio, and his pictures of this time are lighter in style of design, and have less strength of chiaroscuro, than his later works. His second period was that spent at Milan in the service of the Duke Sforza, when he painted his Last Supper. The third was his great Florentine period, from 1500 to 1512, when he executed the famous cartoons of Santa Anna, and of the Battle of Niccolo Piccinino, called the Battle of the Standard; and his own portrait in oils, which is in the gallery at Florence—a work which for painting cannot be surpassed. In the fourth period he was comparatively inactive. In

1512 he returned to Milan; in 1514 (Vasari says 1513) he visited Rome; and in 1516 he went with Francis I. to France, where he died, at Fontainebleau in 1519, aged 67. [VINCI, in BIOG. DIV.]

When Da Vinci returned in 1500 to Florence, the only painter there of extraordinary ability was Fra Bartolomeo di San Marco, or Baccio della Porta, commonly called Il Frate, then in his twenty-ninth year. Michel Angelo was at that time in his twenty-sixth year only, and had done nothing in painting, having confined himself up to that time nearly exclusively to sculpture; which rendered the more remarkable his great success in 1506, in the so-called cartoon of Pisa, executed by order of the gonfaloniere Pietro Soderini, for one end of the council-hall of the old palace of the Signory, for the other end of which Da Vinci made his cartoon of the Battle of the Standard, in which a group of horsemen were contending for some colours, with various accessories.

The good effects of the munificence of Lorenzo de' Medici and his encouragement of the arts did not completely show themselves until after the second restoration of the Medici in 1512. Lorenzo established an academy in his garden near the church of San Marco, and formed a splendid museum of ancient and modern works of art: it was the nursery of all the great artists of Florence of the early part of the 16th century. Some singular scenes were enacted by Savonarola during his short triumph over the general order of things. In 1497, at the time of the Carnival, instead of the usual bonfire in the market-place, Savonarola had a large scaffolding prepared, and upon this he piled many of the most excellent works of the Florentine artists, both in painting and sculpture, including the busts and portraits of several beautiful Florentine females, with many foreign tapestries, condemned on account of their nakedness; and they were all burnt amidst the rejoicings of the populace. In 1498, the following year, he repeated the scene on a much greater scale: on this pile was burnt an illuminated copy of Petrarch. Fra Bartolomeo, Lorenzo di Credi, and other distinguished painters, took part in this fanatical destruction.

Fra Bartolomeo imitated, or rather painted in a very similar style to, Lionardo da Vinci. Several of his works are in many respects admirable, and in composition, in expression, in the cast of draperies, and in design, bear the strongest resemblance to the works of Raffaelle: the great figure of St. Mark, in the Pitti palace, combines with the style of Raffaelle much of the grandeur of the prophets and sibyls of Michel Angelo in the Sistine chapel. Bartolomeo was the true master of Raffaelle: these two great painters contracted a friendship for each other in 1504, when Raffaelle was in Florence and only twenty-one years of age. Bartolomeo died in 1517, three years before Raffaelle. Mariotto Albertinelli followed the style of Bartolomeo, and painted many excellent pictures.

Andrea Vannucchi, called del Sarto from the trade of his father (a tailor), was also one of the most distinguished of all the Florentine painters. He was the scholar of Piero di Cosimo, and had great ability of execution, but he wanted invention. His style in colouring and in chiaroscuro is similar to that of Fra Bartolomeo, but from the study of the cartoon of Pisa he had acquired much of the style of Michel Angelo in design. His easel pictures are very numerous. He died in 1530.

Michel-Angelo Buonaroti, painter, sculptor, and architect, the scholar of Domenico Ghirlandajo, revolutionised painting not only in Tuscany, but in Italy, yet although his style can scarcely be said to have anything in common with that of any of his predecessors, he was anticipated in some of the greatest beauties of composition and design by Da Vinci and by Raffaelle. The chief characteristics of his works are severe grandeur of design and an occasional sublimity of invention: the frescoes of the vault of the Sistine chapel, painted in 1512, are in these respects unrivalled by any other works. The cartoon of Pisa, however, was by some contemporary critics considered to be a superior work in design: it represented many soldiers of Pisa suddenly called to arms when bathing in the Arno, and was a very superior work to the rival cartoon of Lionardo da Vinci. Benvenuto Cellini calls these cartoons the school of the world, so long as they were exhibited to the public: Vasari speaks to the same effect. They were both lost a few years after they were made, in a manner never accounted for. Michel Angelo's was cut in pieces. There is an old print of Lionardo's by Edelinck, made from a bad drawing; and Marcantonio and Agostino Veneziano both engraved parts of Michel Angelo's. The style of Michel Angelo has its faults, independent of an excessive muscular development: he had but one standard of form for man, woman, and child, of every age and every degree; his women are female men, and his children diminutive giants. His great works are his single figures, but his paintings are as statuesque as his statues, and express a similar character: his Moses, his Lorenzo de' Medici, in sculpture; his Daniel, and his Jeremiah or Isaiah, in painting. His Last Judgment, a vast work, but the production of his old age, has the faults of his other works without their grandeur or sublimity; it was finished in 1541, in his 67th year. Michel Angelo made many drawings, but he painted scarcely anything in oil. Though the great works of Michel Angelo were executed at Rome, they influenced chiefly the Florentine school; and the painters of Florence, unlike those of Rome, not being held in restraint in their imitation of Michel Angelo by any veneration for the works of Raffaelle, the imitation was the more palpable, and it was an imitation of *manner* only, not of *style*. The anatomical school is the best designation for the Florentine imitators of Michel Angelo. Francesco Granacci and Daniel Ricciarelli of Volterra, were the least mannered of his scholars. The latter painted with great care, and his Descent from the Cross, in the church of Trinità de' Monti, is reckoned one of the finest pictures in Rome. Another celebrated follower of Michel Angelo was Giorgio Vasari; he is better known however for his lives of the painters, sculptors, and architects, than for his paintings. He executed an immense number of works, but beyond a general correctness of drawing they have nothing to recommend them. Other followers and imitators of his style were Sebastiano del Piombo, Marcello Venusti, Federigo Zuccaro, Francesco Rossi de' Salviati, Jacopo del Conte, Angelo Bronzino, and Allessandro Allori. Painters of this period who were not carried away with the host of imitators were Franciabigio, Jacopo da Pontormo, and Domenico Puligo, scholars of Andrea del Sarto; besides some others of less note: also Il Rosso, or Maître Roux, as he is called by the French.

At the end of the 16th century a new style was introduced by Ludovico Cardi, commonly called Cigoli, which combined careful drawing with brilliant colouring. Santi di Titi preceded him in his indifference towards the anatomical school, and he was greatly assisted in establishing his own style by Gregorio Pagani and Domenico da Passignano. This school was founded upon the style of Baroccio and that of Coreggio, and had much in common with the eclectic school of the Caracci. Its ascendency was promoted by the works of the Venetian Ligozzi at Florence, and by the school of Francesco Vanni at Siena. These painters were followed by younger artists, by Giovanni Biliverti, Fabrizio Boschi, Christofano Allori, Jacopo da Empoli, Giovanni Battista Vanni; also Matteo Roselli and his scholars Giovanni Manozzi da San Giovanni, Baldassare Franceschini, called Il Volterrano, and Francesco Boschi, an excellent portrait-painter; likewise by Francesco Turini and his scholar Simone Pignone; and Lorenzo Lippi, like his friend Salvator Rosa, poet and painter.

Also in a somewhat similar taste of colouring and design, though in a very different style of execution, painted Carlo Dolci; his elaborate finish however is the principal merit of his works; his colouring is often green, yet some of his female heads are executed in exquisite taste. He died in 1686.

In about the middle of the 17th century another change took place in the style of the Florentine painters, as well as in that of the Roman, through the extensive and attractive works of Pietro Berrettini da Cortona, in Florence and in Rome. Cortona was invited to Florence about the year 1637, and was occupied for several following years over his great allegorical frescoes in the Pitti Palace; he left them however unfinished: they were completed by Ciro Ferri, his most distinguished follower. In Florence the style of Cortona attained completely the ascendency, and prevailed the whole of the 17th century and the greater part of the 18th. Cortona paid little attention to expression; his object was to produce a grand effect on the whole: his style was decorative, and his works will not bear inspection in the parts. He is the head of those artists called machinisti by the Italians. His principal followers in Florence were the three Dandini and their scholars, Antonio Domenico Gabbiani and others, and his scholar Benedetto Luti; also Salvi Castelluci, Giacinto and Ludovico Gimignani, Lazzaro Baldi, Allessandro Gherrardini, and Sebastiano Galeotti. Two of the most distinguished Florentine artists of the end of the 18th century were Gio Battista Cipriani and the landscape-painter Francesco Zuccherelli, who both spent some time in this country: also Tommaso Gherardini, who died in 1797, and Pietro Pedroni, who died in 1803, are reckoned among the best painters of their period.

Venetian School.—The historians of Venetian art date the commencement of modern painting in Venice from the 11th century, or about 1070, when the Doge Selvo invited some Greek mosaic-workers to Venice to adorn the church of St. Mark; and in the 13th century, after the taking of Constantinople by the Venetians, in 1204, not only works of art, but artists also, are said to have been plentiful in Venice, Venetians as well as Greeks; only two however of the former can now be named, Giovanni da Venezia and Martinello da Murano. On an old wooden sarcophagus of the Beata Giuliana, in the monastery of San Biagio alla Giudecca, there is a painting of about the year 1262; but the painter's name is not known: it is in a rough style, but Lanzi is of opinion that it is not Greek.

It was not until after the time of Giotto, who executed some works in Padua and Verona in the beginning of the 14th century, that the painters of the Venetian states began to make themselves known by their works. The oldest known works at Padua are by painters of the school of Giotto. The extensive paintings in the church of San Giovanni Battista at Padua are attributed to Giusto Padovano, a scholar of Giotto and a Florentine by birth, though naturalised at Padua. Guariento of Padua was also a follower of Giotto, and was celebrated about 1360: some of his works are still remaining. There are also some works still extant of two celebrated Veronese painters of the same time: of Alticherio da Zevio, near Verona, in the old church of San Giorgio, illustrating the life of St. James; and others of the life of St. John by Sebeto of Verona, in the same church, much in the style of Giotto, especially the former. To these may be added a Jacopo of Verona, who painted some frescoes in San Michel at Padua; and a Gio. Miretto of Padua, who executed some works in the great hall of that place. There were however some painters about this time in Venice and Treviso who painted in what may be termed a national style; and among these may be included the miniature-painters, who were numerous at this time. Among these Zanetti mentions a Maestro Paolo, whose name he found recorded in an ancient parchment with the date of 1346. He is the earliest of the Venetian painters whose time and name are known: there is in the church of St. Mark a picture, or ancona, as it is called, by him and his two sons, divided into several compartments, illustrating the history of our Saviour, with the following inscription:—"Magister Paulus cum Jacobo et Johanne filiis fecit hoc opus." Lanzi says his style reminds us much of the Greek specimens of art. There is another painting by him in the sacristy of the Padri Conventuali at Vicenza, inscribed as follows:—"1333, Paulus de Venetiis pinxit hoc opus." One of the earliest Venetian painters also was a Lorenzo of Venice, who according to Zanetti, was paid 300 gold ducats for an altarpiece, formerly in the church of Sant' Antonio di Castello, now in the Academy, on which is his name and the date 1358. There is likewise in the house of the Ercolani family at Bologna a picture inscribed "Manu Laurentii de Venetiis, 1368:" he was also most probably the painter of the fresco of Daniel in the Lion's Den, in the church of Mezzaratta, near Bologna, marked Laurentius, P.: it was painted about 1370. Another Venetian painter of this time was Niccolo Semitecolo: his name is inscribed as follows upon a painting in the Chapter Library of Padua:—"Nicoleto Semitecolo da Veniexia impense, 1367." This work is a good specimen of the school: it represents the Trinity with the Virgin, and some stories of St. Sebastian: the nude is tolerably well expressed, and the design is bold; but it bears no resemblance to the school of Giotto: it is inferior in design, yet equal in colouring. There are also two pictures by this master in the Academy at Venice. The celebrated Antonio Veneziano mentioned by Vasari executed some works in Venice about this time, but it is disputed whether he was a Venetian or a Florentine. There are a few other old painters of merit of this period whose names are known: Simon da Cusighe, Niccolo Friulano, and Pecino and Pietro de Nova.

In the 15th century a very different style prevailed; and although the artists of this period still designed with great stiffness and in the Gothic taste, they produced many admirably coloured pictures as regards the brilliancy and composition of colour, but in the local colours and reflexes they were yet deficient. The leaders of the improved style were some painters of the small island of Murano, and it has the glory of having been the nursery of the greatest painters of Venice: Titian studied at Murano. The first painters of this place were Quirico, Bernardino, and Andrea da Marano; but its great ornaments were the Vivarini. The oldest of this family is Luigi Vivarini the elder, by whom there is an excellent picture in its style of John the Baptist in the Venetian academy. The next in order of time of this family were Giovanni and Antonio Vivarini, according to Ridolfi and Zanetti, who lived about 1440. That there was a Giovanni Vivarini however is doubted by Lanzi. The only authority for mentioning him is the following inscription upon an altarpiece in San Pantaleone:—"Zuane e Antonio da Muran pense, 1444." But this Zuane is, according to Lanzi, the German known as Joannes de Alemania and Johan Alamanus, which is evident from the two following inscriptions:—"Joannes de Alemania et Antonius de Muriano pinxit," on a picture now in the Academy, formerly in the Scuola della Carità; and "Antonio de Muran e Zohan Alamanus pinxit," on a painting at Padua. The remaining artists of this family were Bartolomeo, the brother of Antonio, and Luigi Vivarini the younger. In the Sala delle Antiche Pitture, in the Venetian Academy, there are several pictures by these masters: they differ little in style from the works of the Bellini. Bartolomeo was the first of the Venetians who painted in oil: his first oil picture is dated 1473; it is in the church of SS. Giovanni e Paolo. In the Scuola di San Girolamo there is an excellent picture of that saint with the lion, by Luigi Vivarini the younger. The principal contemporaries and rivals of the Vivarini in Venice were Jacopo Nerito of Padua and Nasocchio di Bassano the elder, both scholars of Gentile da Fabriano, who was employed in Venice in the beginning of the 15th century; also Jacopo Bellini, Francesco and his son Jacobello del Fiore, and a Morazone: also a Donato, and Carlo Crivelli, scholars of Jacobello. Jacobello attained great celebrity: there are works by him in different parts of the Venetian territory, bearing dates from 1401 to 1432. Donato was superior to his master in style. There was likewise a Vittorio Crivelli, who lived about the end of the 15th century.

Besides the painters already mentioned, there were others of equal merit in other parts of the state, in Bergamo and Brescia. In the former place a Commenduno; in the latter Brandolin Testorino and Ottaviano Brandino; also a Vincenzio Civerchino at Crema; Stefano da Zevio or Sebeto, a painter of great ability, and a Vincenzio di Stefano, his son, at Verona: the latter was the master of Liberale, who became the best painter of Verona of his time. At Verona, also in the latter part of the 15th century, was Vittore Pisanello, who executed many celebrated works in Venice and in Rome, but they have all perished; there are however yet a few of his works at Verona. From the accounts of Pisanello's works, they appear to have been of a very superior description, especially in design. He surpassed all his contemporaries in painting horses and other animals; he was also one of the most famous medalists of his time. Jacopo Tintorello and Marcello Figolino of Vicenza were likewise distinguished artists of this period; the latter painted in an original manner, and if the period assigned to him by Ridolfi be correct, 1450, he had a better knowledge of light and shade and perspective, and a greater delicacy of execution, than perhaps any of his contemporaries. The greatest master however of this period was Francesco Squarcione of Padua, who formed there the greatest school of painters ever brought together by one man: he had 137 scholars, and his museum of drawings and antiques was the richest known at that period. He had himself travelled over the whole of Italy and visited many parts of Greece for the express purpose of making a collection of drawings of the best remains of ancient art. He lived in great affluence, and divided many of his commissions among his scholars. The celebrated illustrated book of anthems in the church of the Misericordia, commonly ascribed to Mantegna, is now by competent judges considered one of the commissions of Squarcione executed by his numerous scholars. There is only one work at Padua known to have been done by Squarcione, painted for the Lazara family in 1452: it is excellent in colouring, in expression, and in perspective. Mantegna, Marco Zoppo, and Jacopo Bellini were scholars of Squarcione.

Trevigi also had its distinguished painters at this time: the following are mentioned by historians: Antonio, Liberale da Campo, and Giorgio da Trevigi: San Vito also had its Andrea Bellunello, who, as his countrymen thought, rivalled both Zeuxis and Apelles. Contemporary with him was Domenico di Tolmezzo.

Towards the end of the 15th century, about 1470, a great change took place in the Venetian method of colouring: the old methods of painting in distemper (*à tempera*), and with gums, &c, (*à guazzo*), were laid aside for what is now generally called oil-painting. This method was introduced into Venice by Antonello da Messina, who had learnt it in Flanders of John van Eyck. Roger of Bruges, likewise a scholar of Van Eyck, is said also to have visited Venice. The first Venetians who distinguished themselves in the new method were the Vivarini and the Bellini. Giovanni Bellini acquired the reputation of the most distinguished painter of his time in Venice: he painted from 1464 until 1516, and executed many works of various degrees of merit, highly finished, brilliantly coloured, but perhaps always in a dry manner; his figures however are frequently well drawn, and his expression was often excellent. Unlike most painters, he improved as he grew old, and condescended to borrow beauties from much younger masters: he endeavoured in his later works to imitate the design and colouring of Giorgione, his own pupil. His elder brother, Gentile Bellini, though very inferior to him, also acquired a great name. He was sent by the Venetian government to Constantinople to paint the portrait of Mahomet II. and other works. The Sultan had sent to Venice for a painter. The school of the Bellini, more particularly of Giovanni, was numerous and celebrated; but as, with the exception of Giorgione and Titian, their scholars painted in a style nearly identical with their masters, it will be sufficient here to mention the names of the principal: Bellin Bellini, Girolamo Mocetto, Nicolo Moretto, Marco Marziale, Giambattista Cima, Giovanni Martini, and Martino da Udine, or Pellegrino di San Daniello. There were others who painted in different styles and belong to other schools. Giovanni Bellini had two distinguished rivals, and perhaps superiors, in Vittore Carpuccio of Venice and Marco Basaiti of the Friuli: some of the works of the latter are the finest specimens of what may be termed the Gothic style that have ever been produced.

The painters of the Venetian states at the end of the 15th century, contemporary with the school of Bellini, were very numerous, and many of them painters of great merit, though more or less followers of the old style. The best were Carlos Cima, Vittore Belliniano, and Jacopo Montagnana: others, who approached nearer to the new style, were Vincenzio Catena, Cordegliaghi, Francesco Bissolo, and Girolamo di Santa Croce.

As the school of Squarcione at Padua was opposed to that of the Bellini at Venice, and its numerous followers adopted a style distinct from that of the Venetian painters, which prevailed elsewhere throughout the state, it is unnecessary to mention them here: the best of them painted in the style of Mantegna, who established a distinct school at Mantua. Francesco da Ponte, a native of Vicenza, and the two Montagna and Bonconsigli, likewise of Vicenza, though born so near to Padua, were followers of the school of the Bellini. Francesco da Ponte was the founder of the Bassanese school: Bonconsigli, called Marescalco, was the best of all the painters of Vicenza of this period. In the Oratorio de' Turchini there is a Madonna on a throne surrounded by four saints by him, which is by some reckoned the finest picture in Vicenza. At Verona, at this time, the beginning of the 16th century, were Domenico Morone and his son Francesco, and also Girolamo da' Libri, who may be reckoned among the best masters of the old school; Girolamo da' Libri was the most celebrated miniature-painter of his time in Italy. Brescia at this period had also its distinguished painters, as Fioravante Ferramola and Paolo Zoppo; and Andrea Previtali, a scholar of Giovanni Bellini, acquired a great reputation at Bergamo. The art of inlaying with stained woods of different colours was practised with much skill at this time: the following artists are mentioned by Lanzi as having attained great distinction for this species of art:—Fra Giovanni da Verona, Fra Vincenzo dalle Vacche, Fra Raffaello da Brescia, Fra Damiano da Bergamo, Gian Francesco Capodiferro, and Bartolomeo da Pola.

Whilst the artists of the neighbouring cities of Venice were with more or less success contentedly following the dry manner of Bellini, it was completely exploded at Venice itself by two of his own scholars, Giorgio Barbarelli di Castelfranco, commonly called Giorgione, and Tiziano Vecellio da Cadore, or Titian. The former was born in 1477, and died in 1511; the latter, born in 1480, died in 1576. Giorgione introduced completely a new style of art: he discarded everything conventional, and worked upon the principle that the exact imitation of the effect of nature as a whole was the true object of a painter, whatever might be the nature or purpose of his representation: the difficulties of execution involved in the carrying out this principle, though a material one, are immense; the greatest of them, however, local colour and tone, are those which the painters of Venice appear to have most fully mastered. Mind has ever been less an object of study with the Venetian artists of this and the following periods, than the mere pictorial representation, which appears generally to have been the end of all their works: they painted for the picture's sake only, not for the lesson or moral that the picture might convey, a style properly designated the ornamental. Giorgione was the first to imitate the textures of stuffs: he painted all his draperies from the actual stuff represented, and painted draperies of many different substances. Before his time all draperies were made of the same material, and differed only in their colours or patterns. He is said to have been first led to the study of tone in light and shade from seeing the works of Lionardo da Vinci. His drawing was good, and his handling bold yet careful. Whether Giorgione, if he had lived longer, would have executed great works, in which every part and object would have been as perfectly executed as some of his single figures and their costumes, must remain a matter of opinion. This excellence was accomplished by Titian, and with a boldness of execution in his best works (in his earliest he finished highly) which far surpasses that of Giorgione; on which account, though originally an imitator of the style of Giorgione, he is deservedly accounted his superior, and is universally considered the founder of the great Venetian school of painting. Titian was in nothing ideal, but true in almost everything that he painted, if not in detail, at least in general effect. His scrupulous imitation of the effect of every object necessarily excluded the ideal from his works; and if his drawing is not the most chaste in style or correct in proportion, it is at least natural, and it is not so inferior that his other excellences do not compensate for its inferiority: in composition he was generally simple, but sometimes grand. In colour, local and absolute, he is allowed to have surpassed all other painters; in landscape, few have surpassed him; in portrait, few have equalled him. His principal masterpieces are considered—a St. Peter Martyr, in the church of Santi Giovanni e Paolo, and the Assumption of the Virgin, in the Academy at Venice; and the Martyrdom of San Lorenzo, at the Escurial in Spain, or at the church of the Jesuits at Venice: his numerous portraits, and Venuses, as they are called, are well known. [TITIAN, in BIOG. DIV.] The scholars of these two great painters were numerous. The following celebrated masters were among the scholars of Giorgione: Sebastiano del Piombo, Giovanni da Udine, Francesco Torbido, called Il Moro, Pietro Luzzo, called Larotto (and by Vasari, Morto da Feltro), and Lorenzo Luzzi. The scholars and imitators of Titian were likewise numerous, but the painters who might be strictly termed his scholars are very few. He is said to have instructed his brother Francesco Vecellio, who was an excellent painter, but Titian, through jealousy, according to report, persuaded him to turn merchant: his own son Orazio Vecellio was likewise a good painter, and there were still four other painters of this family: Marco Vecellio, the nephew of Titian; Tiziano Vecellio, the son of Marco, called Tizianello to distinguish him from Titian; also a Fabrizio and a Cesare Vecellio. Of his scholars, the principal were—Paris Bordone, a painter of the greatest ability; he was only a short time the scholar of Titian, and ultimately adopted a style of his own, though varying in nothing essential from that of Giorgione or Titian.

Two of Titian's most celebrated followers were Girolamo di Tiziano and Bonifazio of Verona, though called Veneziano by Vasari and others. To enumerate the followers of Titian, or Giorgione, or those who imitated the characteristics of their styles, would be to enumerate nearly all the painters of Venice of this period, besides many of those of the neighbouring cities. There are however yet a few names to be mentioned of painters contemporary with the two great leaders of this school, who, though they did not paint in their style, yet executed works which, in point of style of design, brilliancy of colour, and composition, are little inferior to theirs:—Lorenzo Lotto, Jacopo Palma the elder, Giovanni Cariani, and Girolamo da Trevigi, an excellent portrait-painter, who was killed in the service of Henry VIII. of England, at Boulogne in 1544. One of the most distinguished contemporaries of Titian also, and his chief rival in Venice, was Gian Antonio Licinio (born 1484, died 1540), commonly called Pordenone, from the place of his birth in the Friuli. He painted much in the style of Giorgione, but with still greater force of light and shade; and he was also one of the best of the Venetian fresco-painters. There were many in Venice who considered that Pordenone surpassed Titian: Zanetti, in speaking of these two rivals, says, in the style of Pordenone there is as much manner as nature, in that of Titian nature predominates. Pordenone formed a numerous school: Pomponio Amalteo was the most distinguished of his scholars, who himself also had many scholars, of whom Sebastiano Seccante was a distinguished painter. The following imitators of the style of Titian are all deserving of mention:—Andrea Schiavone di Sebenico, called Medula; Ludovico Fiumicelli, of Trevigi; Francesco Dominici, also of Trevigi; Gio. Battista Ponchino, of Castelfranco; Damiano Maza and Domenico Campagnola, of Padua; Giambattista Maganza, in Vicenza; Alessandro Bonvicino, called Il Moretto di Brescia (a painter of superior powers—he formed several good scholars); and Romanino Savoldo Gambara and Pietro Rosa, of Brescia—the first was the master of Girolamo Muziano, who afterwards distinguished himself at Rome; the second was known at Venice as Girolamo Bresciano. There were also many other painters of merit, of the school of Titian, in various other cities of the Venetian state; but the limits of this article will not admit of them all being enumerated by name.

It remains yet to mention three of the greatest ornaments of the golden age of Venetian painting, as this period is called—Jacopo Robusti, called Tintoretto; Jacopo da Ponte, called Bassano; and Paolo Cagliari, called Veronese. Tintoretto (born 1512, died 1494), so named from the trade of his father, a dyer, is generally called the pupil of Titian, but he remained only twelve days with him, and this at a time when he was very young. [TINTORETTO, in BIOG. DIV.] He professed to colour like Titian, and to draw like Michel Angelo; his practice however did not accord with his profession, for compared with Titian, he was cold in colouring, and extremely heavy in light and shade; he was fond of violent contrasts and great masses of light and shade; in design, though muscular, he was often lean and incorrect; and in his compositions he was fond of many figures, generally thrown together without arrangement. He was however extremely unequal in his works, some of which are amongst the finest productions of the Venetian school; his masterpiece is generally considered the Miracolo dello Schiavo, in the Academy at Venice: he put his name to this picture and to the two following—the Crucifixion, at San Rocco, and the Marriage at Cana, in the Church of Santa Maria della Salute. Many of Tintoretto's greatest pictures are merely dead-coloured, and that in a most careless manner: he was extraordinarily rapid in his execution,—he acquired the name of Il Furioso in consequence: Sebastian del Piombo said that Tintoretto could do as much in two days as he could do in two years. Bassano (born 1510, died 1592) commenced as an historical painter in the grand style, and as an imitator of Titian; but after he left Venice he changed it for an original style of his own in the characteristic style of the Dutch painters, and he was the first to introduce the taste for such works into Italy. He painted landscapes, animals, domestic scenes, kitchens, &c., and the various utensils for drinking, &c., particularly of brass. In the church of Santa Maria Maggiore at Venice is a Sacrifice of Noah, in which he introduced all the birds and animals that he had drawn elsewhere: his greatest excellence was his colouring. He brought up four sons as painters, but they were inferior to their father. Paolo Veronese (born 1528, died 1588), though in his principles of colouring identical with the other great masters of Venice, from the splendour of his great compositions may be said to have formed a new style of his own. He was fond of crowds of people, arrayed with all the pomp and splendour that the imagination and colour could accomplish, filling his backgrounds with piles of the richest architecture. He was however, as Algarotti says, careless in design, and in costume extremely licentious; but his fancy was noble, his invention inexhaustible, and even his faults are pleasing: one can scarcely look at his magnificent pictures without longing to be a party in the scene. One of his grandest compositions is the Marriage at Cana, in the Louvre—a vast composition, more than 20 feet high, and upwards of 30 wide: it contains about 150 heads, many of which are portraits of the most illustrious and distinguished persons of his time. Another of his chief works, 'the Family of Darius,' is in the National Gallery. Paolo Veronese was the real master of Rubens. Verona had at this time three other painters little inferior to Paolo himself: Battista d'Angelo, called Del Moro, scholar and son-in-law of Torbido; Domenico Ricci, called Brusasorci; and Paolo Farinato, called degli Uberti.

Of the assistants and scholars of Paolo the most distinguished were his brother Benedetto Cagliari, who generally painted his architecture for him; his son Carlo Cagliari, called Carletto, who died young; Gabriele Cagliari, likewise his son; and Battista Zelotti, the most distinguished of all his followers.

After the time of the great masters just spoken of, in the 17th century the Venetian school of painting declined as much and as rapidly as the Florentine did after the time of Michel Angelo. Many of the Venetians of this period, mistaking apparently brilliancy for art, cultivated little besides colour, and many of their pictures are mere compositions of silks, satins, and other stuffs. There were however several good painters during this period of decline. Jacopo Palma the younger (born 1544, died about 1628) holds a middle place between the great painters of the last period and the mannerists of this. Lanzi calls him the last of the good age and the first of the bad. He painted somewhat between the styles of Tintoretto and Paul Veronese; had many defects and many beauties, and produced many bad and several admirable pictures. Marco

Boschini, painter and engraver, was a scholar of Palma; he is known for an uncritical work on painting, principally on the style and works of the Venetian painters of his own and former times, entitled "La Carta del Navegar Pittoresco." The following painters were the principal contemporaries of Palma, who painted somewhat in his style: — Leonardo Corona, Andrea Vicentino, Santo Peranda, Antonio Vassilacchi, called L'Aliense: Pietro Malombra, and Girolamo Pilotto. Giuseppe Porta, called Salviati, Matteo Ponzone, the scholar of Peranda, and Pietro Damini. scholar of Gio. Battista Novelli, were likewise three of the best painters of this time.

In 1630 and 1631 many painters were carried off by the plague, which visited Venice in those years; and traces of the excellences of the great masters were after that time still more rare in the works of the surviving painters of Venice. In the middle of the 17th century the style of M. A. Caravaggio and the Naturalisti began to prevail there, and several foreigners supplanted the Venetian painters in public estimation in Venice itself. The followers of Caravaggio in Venice were, on account of their dark shadows, called by the Venetian painters the Tenebrosi: the pictures of the masters of this school are dark from two causes—from their style of colouring and from their practice of painting upon dark grounds, upon which the middle tints never stand. The pictures painted on such grounds darken after a time, and high lights and deep shadows are all that appear. Of these Naturalisti and Tenebrosi, Pietro Ricchi of Lucca, called Il Lucchese, was one of the best; others were Carlo Saraceni, Francesco Rusca, Stefano Pauluzzi, Matteo da' Pitocchi, and Bastiano Mazzoni. Of strangers distinguished in other styles the following were the most successful:—Antonio Triva of Reggio, a scholar of Guercino; Bernardo Strozza, his scholar Langetti, and Niccolo Cassana, of Genoa; Antonio Bavarense, of Bavaria; and Federigo Cervelli, of Milan, the master of Sebastiano Ricci. The painters of this period who still followed the style of the great leader of the Venetian school were Giovanni Contarino and his scholar Tiberio Tinelli, celebrated portrait painters; also Girolamo Forabosco, Pietro Bellotti, and Carlo Ridolfi, well known for his Lives of the Venetian painters, 'Le Maraviglie dell' Arte, ovvero le Vite degli illustri Pittori Veneti e dello Stato,' 2 vols. 4to., Venice, 1648, which is one of the best of the Italian works of this kind. Ridolfi was a native of Verona, where, of all the cities of the Venetian state, what is more properly the Venetian style still prevailed with least deterioration. Dario Varotari, the father of Alessandro, called Padovanino, Alessandro Turchi, called L'Orbetto, and Pasquale Ottini, all amongst the best painters of their time, were natives of Verona.

Padovanino (born at Padua, 1590, died 1650) went young to Venice to study the works of Titian, and became the most distinguished painter of this school of the 17th century, and is one of the best of Titian's imitators: his masterpiece is the Marriage at Cana, in the Academy at Venice. Scaligero, his principal scholar, also acquired reputation.

Another great painter of Padua of this time was Pietro Liberi, sometimes called Libertino, from the character of his naked Venuses, of which he painted many. At Vicenza the beauties of this school were still preserved to a considerable degree by Alessandro Maganza, an imitator of Paul Veronese and Zelotti; Francesco Maffei, scholar of Peranda; Giulio Carpioni, scholar of Padovanino; and Bartolomeo Cittadella, the scholar of Carpioni.

At the end of the 17th century no particular style prevailed in Venice, and all the various classes of painting had their votaries: landscape, architecture, battle, and marine painters were alike numerous. Zanetti states that there were as many styles as painters in Venice at the end of the 17th century. In historical painting however the works of the Bolognese painters as in almost every other city at this time, were likewise in Venice the chief objects of attraction. Still, says Lanzi, the old masters were not on this account underrated, but were spoken of as the ancients of a golden age, whose customs were to be praised, but not imitated. The colouring of the painters of this period in Venice was more brilliant than that of the great masters, but what they gained in brilliancy they lost in truth: in drawing, however, and in costume some of these painters had the advantage of their predecessors, but in these respects the Venetians were never very distinguished. Of these painters the following may be mentioned: Andrea Celesti, who painted sometimes in the style of Caravaggio, but more generally in the style of Paul Veronese than of any other master; and Antonio Zanchi of Este, better known for the number than esteemed for the merit of his works, painted likewise sometimes in the style of Caravaggio and sometimes in that of Tintoretto. In the Scuola di San Rocco there is a celebrated picture by him of the Plague of Venice in 1630, and opposite to it in that place there is a picture of the Liberation from the Plague, by his scholar Pietro Negri. Francesco Trevisani was also one of his scholars, but he settled early in Rome. To these may be added the names of Antonio Molinari, Antonio Belluci, Giovanni Segala, Gio. Antonio Fumiani, and Niccolo Bambini. The last was the scholar of Carlo Maratta in Rome, and many of his pictures are painted entirely in the Roman style. But a more distinguished painter and a better draughtsman than any of these was Gregorio Lazzarini, who painted in the style of the best Bolognese and Roman painters of the period, though he never left Venice. Antonio Pellegrini acquired a name in various countries of Europe. Jacopo Amigoni also attained great celebrity, less in Venice, however, than in England, in Germany, and in Spain; his pictures are extremely bright and brilliant. Other distinguished painters of this age entitled to be mentioned were Giambattista Pittoni and Giambattista Piazetta: the former was celebrated for his powerful effects of light and shade in the manner of Guercino, but through a bad method of colouring, his pictures in a short time lost all their beauty in this respect; his execution was rapid and careless. He was a good caricaturist, and he was remarkably popular in his time. One of the scholars of Piazetta, Giambattista Tiepolo, was the last of the Venetians who acquired a great name. He was one of the best painters of the 18th century, and acquired a great reputation in Italy, in Germany, and in Spain, where he died at Madrid about 1770. He excelled chiefly in fresco, and he painted more in the style of Paul Veronese than that of Piazetta. [TIEPOLO, in BIOG. DIV.] He had a distinguished scholar in Fabio Canale. Although Tiepolo may be termed the last of the great Venetian painters, there were still several perhaps of equal ability in the state. Before mentioning these however, we have yet to notice one of the greatest painters of the 18th century, who, though not a Venetian, was first educated at Venice by Cervelli, Sebastiano Ricci, or Rizzi, born at Cividal di Belluno in 1660, and died in 1734. He travelled over Italy, and visited Germany, England, and Flanders, and earned the reputation of a great painter wherever he went. He had a great facility in imitating the styles of other masters: he painted in fresco and in oil. His colouring was rich and agreeable, though he occasionally introduced too much azure in his draperies. His composition and design were graceful; in design he was better than the Venetians: his handling was free and yet not careless. His nephew Marco Ricci was a distinguished landscape painter. Ricci had several scholars: the most distinguished were Gaspero Daziani and Francesco Fontebasso.

It remains now only to mention the distinguished painters of the Venetian state, in the 18th century, not already noticed. Antonio Zifrondi of Bergamo, a painter of remarkable facility of execution; and of the same place, Fra Vittore Ghirlandi and Bartolomeo Nazzari, were both excellent portrait painters. In Brescia, Avogadro Bresciano was distinguished for rich colour, elegant composition, and good drawing; likewise Andrea Toresani, but he practised more in Venice and Milan than in Brescia: he was distinguished for landscapes and marine pieces, which he embellished with figures and animals painted in excellent taste. Simone Brentana, though a native of Venice, was domiciliated at Verona, and painted many excellent works there. Of Verona also was Antonio Balestra, who studied at Venice, at Bologna, and at Rome with Carlo Maratta: he painted less in the Venetian taste than in the Bolognese and Roman; he drew well, composed with judgment, and executed many excellent works: Gio. Battista Mariotti, Giuseppe Nogari, and Pietro Longhi, Venetians, were his scholars. The first was a good imitator of his style; the second excelled as a portrait painter, but painted also some historical pieces; the third was distinguished for masks, conversations, and landscapes. Carlo Salis of Verona, and Cavalcabo of Roveredo, both painters of great merit, were likewise the scholars of Balestra; and also another Veronese painter, one of the best of the 18th century, Il Conte Pietro Rotari: he excelled in every department of painting except colouring, yet in this respect he was harmonious; his colouring was ashy and melancholy; he died at St. Petersburg in 1762, painter to the empress Catherine II. of Russia. The last of the distinguished painters of Verona was Gio. Bettino Cignaroli, likewise instructed by Balestra: he drew also in the style of Maratta; his masterpiece is perhaps the Flight into Egypt, at St. Antonio Abate at Parma: he died in 1770. The emperor Joseph II. is reported to have said, that he had beheld two very rare things in Verona—the amphitheatre, and the first painter of Europe.

Santo Prunati of Verona, contemporary with Balestra at Verona, was also a good painter; and there was a Pietro Uberti at Venice, an excellent portrait painter. A very distinguished painter also of this period at Venice, though of a different class, was Antonio Canaletto, known throughout Europe for his views in Venice, and other cities in and out of Italy.

Roman School.—That style of art which was eventually formed, or prevailed, at Rome during the golden age of painting, in the beginning of the 16th century, is termed the Roman school, whether it was practised by subjects of the papal government, natives of the city of Rome, or strangers resident there. The simple fact however, of having practised the art of painting in Rome, does not constitute a disciple of that school. The works of Raffaelle exhibit this style in its full development or most perfect form, and he is accordingly the head or representative of the Roman school.

In retracing the progress of the Roman school, we must go back to that original school of Italian painting, which flourished in the 14th century in various cities of the Roman states, within the limits of ancient Umbria,—in Gubbio, Fabriano, Maselica, Borgo S. Sepolcro, Urbino, Assisi, and other places,—and thence termed the Umbrian school.

Oderigi of Gubbio, one of the old practitioners of missal-painting, an art which was never quite extinct in Italy, seems to be the most ancient painter of this school whose period is ascertained with any degree of certainty; he died about A.D. 1300. Oderigi appears to have been an active reviver of painting, and he was a man of reputation in his day. He is mentioned honourably by Dante, who terms him "L'onor d' Agobbio, e l'onor di quell' arte."

There is mention also of three other ancient painters of Gubbio: Cecco and Puccio, who were employed in 1321 in painting the dome of Orvieto; and Guido Palmerucci, who was employed about 1324, in the town-hall of his native city.

A still more important name in the early history of the Roman school is that of Pietro Cavallini, who is said to have received instruction from Giotto while at Rome. A Crucifixion by this master, still extant at Assisi, is a remarkable production. The return of the papal government from Avignon to Rome gave a new impulse to the arts; the most skilful artists were sought throughout Italy to decorate the temples and palaces of the luxurious pontiffs of Rome. Of these the principal were Ottaviano Martis, and Gentile da Fabriano, a master of much greater merits. Fabriano was surnamed Magister Magistrorum, and practised his art in many parts of Italy. In 1417 we find him engaged at Orvieto; he resided afterwards at Venice, where he obtained the rank of patrician, and was the master of Giacopo Bellini, whose sons were the founders of the Venetian school. His style, which by Michel Angelo was pronounced to be, like his name, "Gentile," somewhat resembled that of Fra Angelico da Fiesole, though it was much inferior to it.

Piero della Francesca, or Piero Borghese, advanced the art still further; he was reckoned one of the best geometricians of his time, and was the first Italian who had any knowledge of the principles of perspective. He introduced immense improvements in the management of draperies, and also greatly enlarged the manner of treating the naked figure. Bramante studied the works of Piero, who was fond of introducing architectural backgrounds in his pictures, which he executed in tolerable perspective. Additional improvements were made by Bartolomeo Corradini of Urbino, called Fra Carnevale, who gave great character to his heads, and was the first to introduce portraits into historical compositions, in which practice he was afterwards followed by Raffaelle, who paid great attention to the works of this painter at the commencement of his career.

Niccolo Alunno of Foligno and Benedetto Bonfigli complete the list of the considerable artists of this school previous to and contemporary with Pietro Perugino, the master of Raffaelle, and Giovanni Sanzio of Urbino, his father. Although, through the united efforts of the above masters, painting had attained to many high and pleasing qualities, true taste in design may be said to have totally failed them. They had not yet discovered what was beautiful and what was not, or what belonged to the individual and what to the class. Their art was not truly imitative, nor does it seem that an appearance of reality was an object with these painters; they seem to have considered that their end was sufficiently accomplished in an intelligible indication of whatever they represented. The deficiency of this school could only be supplied through the study of the antique, and to supply it in a great degree was a distinction which fell to the lot of Masaccio, who must be looked upon as the leader of the great painters of the 15th century, or the Quatrocentisti, as the Italians have termed them, among whose works we first perceive any distinctive characteristics of style.

It cannot be denied that Perugino owed his great superiority over his predecessors to his visit to Florence, where, whether he became the pupil of Verocchio or not, which is a matter of dispute, he was at least enabled to study the noble works of Masaccio. His taste was however still dry and mean, his design was meagre and feeble, though often correct, his draperies were stiff and in a little manner, yet his colouring was sometimes exceedingly rich, and for graceful delicacy of attitude and motion, and a softness and simplicity of expression, he surpassed all his contemporaries. But there is a symmetrical repetition and similarity in the disposition of his figures, which betray a total absence of anything like vigour or truth of composition, and which place him at an immeasurable distance from his great scholar. No pupils ever imitated their master so closely as, with the exception of Raffaelle, did those of Perugino; and many of their works are reputed works of their master. His most celebrated scholars were, Bernardino Pinturicchio; Andrew Luigi of Assisi, called L'Ingegno on account of his great abilities, who became blind when still young; Domenico and his son Orazio di Paris Alfani; Eusebio da S. Giorgio; Giannicola da Perugia; Lo Spagna; Berto di Giovanni; Sinibaldo da Perugia; Adone Doni of Assisi; and Palmerini of Urbino. The works of all these masters were more or less conspicuous for symmetrical composition and a profuse application of gold.

We now arrive at the pride of Perugino and the glory of the Roman School, Raffaello Sanzio d'Urbino, the first of painters; for moral force in allegory and history, unrivalled; for fidelity in portrait, unsurpassed; who has never been approached in propriety of invention, composition, or expression; who is almost without a rival in design; and in sublimity and grandeur, inferior to Michel Angelo alone, whose prophets and sibyls in the Capella Sistina are in these respects unquestionably the triumphs of modern art.

It must not be supposed that Raffaelle attained these great qualities intuitively: they were the result of long and intense application; and in the works of no artist is the progress of improvement so apparent as in those of Raffaelle. He painted in three styles: his first was that of Perugino. His second was an enlargement of that style in the taste of Fra Bartolomeo, and is termed his Florentine; but this change or improvement in style was not effected through an acquaintance with that great painter alone, but also through the impression made upon Raffaelle's mind by the works of Masaccio, of Lionardo da Vinci, and also of Michel Angelo, at Florence. His third style, which is the subject we have now more particularly to consider, was peculiarly his own; although those magnificent works the Prophets and Sibyls of Michel Angelo were the principal causes of its ultimate fulness and grandeur. This third style, which is the proper style of Raffaelle, constitutes the Roman school in its full development, which is the least defective of all the schools of painting.

There is a degree to which the powers of imitation may be combined with those of the imagination, which, when regulated by a just refinement of feeling or taste, constitutes the perfection of painting, and this degree, though not attained, was in the aggregate approximated more nearly by Raffaelle than by any other painter. He never designed a figure which he did not inspire with appropriate sentiment; the affections of mankind were the sphere of his genius; from the calculating sage to the thoughtless infant, his works are the history of the human heart, and deservedly has he been entitled the "painter of the passions." The elements of his style are nowhere more apparent than in the Cartoons at Hampton Court. To particularise amidst so much excellence, and to single out the works in which Raffaelle has been most eminently successful, is rather a delicate task; yet perhaps the following examples may be instanced as being more decidedly conspicuous for those particular qualities which characterise his style:—for grandeur of design, the Heliodorus; for sublimity of character and conception, the Madonna di San Sisto; for composition and expression, the Cartoons; and perhaps for invention and general technical excellence, the Transfiguration, his last performance. [RAFFAELLE, in BIOG. DIV.]

The style of Raffaelle has seldom been found congenial to their taste by the lovers of colour, and certainly those who consider the perfection of painting to consist in splendid colouring must not look for it in the works of the Roman school, but in those of Paul Veronese or of Rubens. Many critics have regretted that Raffaelle did not colour like Titian; but colour was to Raffaelle a *means*, and not an *end*, as it was with the majority of the Venetian painters; and its effect is to dazzle and to obscure, rather than to enhance the essential qualities of the grand style. For as the painted face of a player harmonises with the accompanying spectacle and the tone of light around, and would as certainly be ridiculous if exposed to the light of day, so the Venetian colouring, which is in such perfect harmony with the subjects of that school and their general treatment, would as certainly be in discordance with those qualities which characterise the style of Raffaelle. Even Ludovico Caracci, the founder of the Eclectic school of Bologna, discovered that Venetian colouring was inapplicable to the subjects which he chose for his own pencil. And Raffaelle would not have been the great painter that he proved himself to be, had he chosen any other than the sombre colour for which he is so conspicuous, and which, so far from being a defect in his style, is indeed an additional evidence of his profound genius. These remarks do not refer to the carnations particularly, which should always harmonise with the draperies, but to the composition of colours generally, to their choice and intensity, and also to the stuffs and materials of which the draperies are composed. Raffaelle rarely if ever painted silks or satins; most of the Venetians seldom painted anything else.

Raffaelle had many scholars and many imitators; of the former, the principal were Giulio Romano, Gianfrancesco Penni (with Giulio, Raffaelle's principal heir), and Perino del Vaga: these painters completed, from Raffaelle's designs, the great works in the Vatican, which he had left unfinished.

Giulio Pippi, called Giulio Romano, certainly the most eminent of all Raffaelle's scholars and imitators, was conspicuous for the correct and powerful design of his master, but in other respects he never approached him. Although he had great powers of invention, an unpleasing expression and an evident absence of sentiment prevail throughout his works. He is also heavy both in design and colouring; but his particular employment under Raffaelle, that of dead-colouring and preparing his works in oil, may have greatly contributed to this effect. Giulio left Rome during the pontificate of Clement VII., shortly after the completion of the Constantine series in the Vatican, and, at the invitation of Federigo Gonzaga, repaired to Mantua, where he founded a school and painted his famous works, the Fall of the Giants, and the Loves of Cupid and Psyche. [GIULIO ROMANO, in BIOG. DIV.]

Gianfrancesco Penni, with little less vigour than Giulio, was conspicuous for more of the grace of his master. Pierino Buonaccorsi, called Perino del Vaga, displayed nearly equal powers. Other pupils and assistants of Raffaelle in the stanze and the loggie of the Vatican, were—Giovanni da Udine; Polidoro Caldara da Caravaggio, celebrated for his imitations of ancient bassi rilievi; Pellegrino da Modena; Bartolomeo Ramenghi, called Il Bagnacavallo; Vincenzio di S. Gimignano; Timoteo della Vite; Raffaellino del Colle; Benvenuto Tisi, called Il Garofolo; and many others too numerous to mention here.

The accession of Adrian VI. to the papal chair had for a time paralysed the arts, but they were shortly inspired with new vigour by his successor Clement VII., Guilian de' Medici, who continued the works that had been interrupted by Adrian. But a more serious interruption succeeded in the sack of Rome, in 1527, by the soldiers of

Bourbon. The vast school of painters formed by Raffaelle was totally dispersed: it spread however the elements of his style all over Italy, although scarcely a single beauty of the original was to any extent preserved in the copies.

In the pontificate of Paul III., the arts commenced again to revive in Rome. Michel Angelo executed his great work of the Last Judgment, the labour of eight years, by the orders of this pontiff: it was completed in 1541. The effect however of this work was for a time fatal to painting; hosts of copyists and mannerists arose, who, possessed with a mania for representing the naked figure, and sacrificing everything to anatomical display, imagined the perfection of design to consist in violent action and muscular protuberance; and in imitating the *manner*, they imagined they had acquired the *art* of Michel Angelo. This great painter, who in the time of Julius II. had himself been chiefly instrumental in raising painting nearer to perfection than it has ever attained in modern times, lived also to see it degenerate, greatly through his own influence, into a mere handicraft in the time of Pius IV., when a reference to nature was considered as an acknowlegment of a want of genius.

The most distinguished mannerists of this school and period, whose style was a species of compound of those of Raffaelle and Michel Angelo, without the correctness or purity of the former, and with only the manner of the latter, were Taddeo and Federigo Zuccari. The former died young. The latter executed vast works at Florence, which were, however, remarkable for their vastness alone; and he has left specimens of his pencil in the principal cities of Italy. He succeeded Girolamo Muziano as president of the Academy of St. Luke at Rome, which had been lately founded by Gregory XIII. at the instance of Muziano. Gregory was elected in 1572.

The following exceptions should be mentioned, as being distinguished for their greater propriety of style, from the general host of mannerists:—Girolamo Siciolante of Sermoneta, Marcello Venusti, and Livio Agresti, all scholars of Perino del Vaga; also Scipione Pulzone, called Gaetano, the scholar of Giacopo del Conte, both excellent in portrait.

Guiseppe Cesari d' Arpino succeeded Federigo Zuccaro in public estimation at Rome; but though without a rival in that city until the appearance of Michel Angelo Amerighi, Il Caravaggio, he cannot be said to belong to the Roman school. The heavy and vulgar nature of Caravaggio's style was in direct opposition to the ideal mannerism of Cesari's. They both had their partisans, who were termed respectively naturalisti and idealisti; the latter prevailed. Annibale Caracci also endeavoured in vain to reform taste in Rome: the works of this great master in the Palazzo Farnese had little or no effect upon the style of the Roman painters of the period, and Cesari left a numerous school of imitators. But these noble works, certainly inferior only to those of Michel Angelo and Raffaelle in Rome, eventually had their effect, and painting was again restored to something approaching its former splendour; and what the painters of Bologna had borrowed from the Romans in the pontificate of Clement VII., the pupils of the Caracci returned with interest in that of Urban VIII.

A better style was adopted by Federigo Baroccio of Urbino, which might boast of a nearer approach to the correctness of form of the great founder of the Roman school; but his colouring was generally artificial, and very different from that of Raffaelle. Its tone is unpleasant, a cold violet hue prevails throughout, and there is a striking deficiency of yellow in his carnations, which in the lights are pink, in the shadows gray. Baroccio had several imitators, but his influence upon the general character of Roman art was inconsiderable. The Eclectic school of Bologna seems to have had the principal share in reforming the art in Rome. During the pontificates of Paul V., Gregory XV., and Urban VIII., the celebrated pupils of the Caracci, Domenichino, Guido, Guercino, and Lanfranco, were much employed by those pontiffs; and the example of these great masters, but more especially of Domenichino, produced many good painters, of whom we may mention the following:—Antonio Ricci (called Barbalunga), Camassei, Giovanni Carbone, Francesco Cozza, Pietro del Po, Canini, Giambatista Passeri, and Luigi Scaramuccia, and there were many others of considerable merit. The school of the Caracci seems to have had a more immediate influence upon portrait-painting, truth or fidelity of representation being indispensably requisite to constitute excellence in portraiture. The excessive mannerism of the painters of the period had so generally incapacitated them for executing anything excellent in that department, that it began to be nearly a distinct profession, and the following masters distinguished themselves as excellent portrait-painters, though they did not confine themselves quite exclusively to portraits:—Antonio di Monti, Pietro Fachetti, Antonio Scalvati, Grammatica, Ottavio Leoni, and Baldassare Alloisi, called Galanino.

Upon the imitators of Domenichino followed the bold style of Lanfranco, whose most successful scholar was Giacinto Brandi; and contemporary with Lanfranco flourished Albano in Rome. Pier Francesco Mola was an imitator of his style.

From the studio of Albano came Andrea Sacchi, a painter who drew well and coloured admirably, who never bestowed labour upon a trifle, and who was better versed in the theory of art than any of his contemporaries or immediate predecessors. There is a grandeur about his style, and a truth and breadth in his execution, which distinguish him as one of the noblest disciples of the Roman school, second only to Giulio Romano in invention, and in all other respects inferior to its great founder alone. Raffaelle was his model of perfection; but he was no servile imitator: he could appreciate also the beauties of Titian and of Correggio; and he had recourse to the same sources through which his great model attained to excellence—nature and the antique, but he availed himself only so far of the antique as it served to regulate his study of nature.

No inconsiderable ornament also of the arts of Rome of this period was Nicholas Poussin, for though a Frenchman by birth, he was essentially a Roman painter. He formed his style from Raffaelle and the antique. He attended also the academies of Domenichino and of Sacchi, being a great admirer of the works of those masters. His style was however very peculiar, and had no influence upon the arts in Rome; his works have too much the appearance of painted bassi-rilievi.

Pietro Berrettini, called also Pietro da Cortona, set himself up as the rival of Sacchi in Rome; and if the number of imitators is a criterion of the degree of excellence, Pietro da Cortona was certainly superior to Sacchi. The art of Sacchi was not so easily imitated. The style of Cortona was rich and attractive, but superficial and incorrect, and he takes the lead in that class of painters termed machinists by the Italians.

The scholars of these two masters formed two rival factions of art, which divided Rome: that of Sacchi was headed by Carlo Maratta, supported by Ludovico Garzi; that of Cortona by Ciro Ferri, supported by Romanelli. Bernini, who, during the pontificates of Urban VIII. and Innocent X., in matters of art was all-powerful in Rome, opposed, as was to be expected, that party which was conspicuous for good taste; and for a time the machinists prevailed. But the school of Cortona was predominant only in fresco, for in oil Maratta was unrivalled. In 1689, however, Ciro died, and Maratta stood alone; and upon the accession of Innocent XII., in 1691, he was appointed inspector of the stanze of the Vatican, and in 1702, by the orders of Clement XI., he restored the works of Raffaelle in those apartments, which had considerably suffered through time and neglect. He had restored previously the frescoes of Annibale Caracci in the Palazzo Farnese. He died in 1713. His style was generally considerably less vigorous than that of Sacchi, and both his colouring and his composition were occasionally artificial; his drawing was also sometimes incorrect; and his taste was upon the whole very inferior to his master's, though his style has been termed more graceful.

Maratta formed a most numerous school, but its chief characteristics were the studied composition and affected grace which are the blemishes of his own style.

Maratta has been termed the last of the Romans, and perhaps he may be safely termed the last of the Romans who has merited the name of a great painter; for neither Pompeo Batoni nor Mengs can be said to dispute that claim with him, though both are deservedly celebrated names. The former gave too much importance to high finish; the latter was too blindly devoted to the antique. Batoni painted excellent portraits, and Mengs drew correctly, but he was so eager after the ideal that he lost nature in the search of it; in this respect Batoni has greatly the advantage over Mengs. They were both eminently academic, and for mere technical excellence have not often been equalled; but there is a palpable absence of the "mens divinior" and moral sentiment in their works, which are more than ordinarily conspiuous for that insipidity and monotony so generally attendant upon the fastidious preciseness of academic art.

The Bolognese School divides with the schools of Tuscany, Rome, and Venice, the honour of having assisted in bringing about the great revival of painting in Italy in the 13th century. But unlike them its advance was slow; it had no great painter to share in the glory of that brilliant epoch, the beginning of the 16th century, when the greatest masters of Italian painting flourished contemporaneously. Its culminating point was reached much later, and then hardly as the result of original genius. The school of Bologna is chiefly remembered as an eclectic school. Its heads, the Caracci, sought to achieve the highest excellence by imitating and combining the peculiar excellencies of the great masters of other schools: and in the opinion of their contemporaries they succeeded. Not only by their countrymen, but by the painters of other schools their principles were adopted; and their influence thus extending throughout Italy, and coinciding with the tendencies of the age, served to repress what little originality remained and to produce everywhere a uniformity of academic mediocrity. This school is therefore historically one of the most important in modern art, but we need not speak further of it here, having already treated of it under Bolognese School of Painting.

Of other Italian schools our notice must necessarily be very brief. Chief of these are the *Schools of Lombardy*, which however are so broken up and subdivided, almost every city claiming a school of its own, that even if our space permitted, it would be tedious to retrace so often the same ground as would be necessary in speaking of them however cursorily. Lanzi has given the history at length of no less than five Lombard schools; those namely of Mantua, Modena, Parma, Cremona, and Milan. Of these the most famous, as having produced Correggio and so imparted a distinct character to Lombard painting, is that of Parma. But Andrea Mantegna, a native of Padua (born

1431, died 1506) must be considered as the true founder of Lombard painting, he having settled in Mantua and established there the school whence proceeded many of the chief painters who have adorned the schools of Lombardy. Mantegna's most famous paintings are his 'Virgin and Saints,' and 'Victory,' both in Mantua, but what Vasari and his contemporaries regarded as his masterpiece, the series of designs in water-colours, entitled 'The Triumph of Julius Cæsar,' is now in Hampton Court Palace. The great influence of Lionardo da Vinci on the schools of Lombardy has been already noticed in speaking of the Tuscan school.

Antonio Allegri, or, from his birth-place, Correggio (b. 1494, d. 1534), may have been instructed in the school of Mantegna, though after the death of Andrea, but he probably learnt more from the works of Lionardo da Vinci in Milan, and from the practice of that master's scholars; and he appears to have studied the paintings of Giorgione and Titian. Nothing in the history of art seems so *premature* as the style of Correggio. His early pictures at Dresden show the same colouring which he afterwards carried to such perfection. His feeling for grace, tenderness, and delicacy of expression led him sometimes to the verge of sentimentalism; but nothing can be purer or more refined in feeling than some of his best works. Of colour and chiaroscuro his mastery was perfect. No other artist ever played with light and shadow as he was wont to do. His half tones and his reflected lights produce the effect of illusion. He knew his power, and delighted in displaying it in the conquest of difficulties from which other masters shrank. The finest works of Correggio are the frescoes in the cathedral of Parma, and in the convent of St. Paul, in that city, the Notte and other pictures at Dresden. In the National Gallery are some very fine easel pictures by him, especially the 'Ecce Homo,' 'Venus instructing Cupid,' and the 'Vierge au Panier.' [CORREGGIO, in BIOG. DIV.] The tendency to affectation visible in Correggio was a dangerous legacy to the school of Parma, and its evil consequences are especially visible in the works of Francesco Mazzola, or Il Parmigiano (b. 1503, d. 1540), to whom however it is impossible to deny great power and great feeling for beauty. [PARMIGIANO, in BIOG. DIV.] But the influence of Correggio was not lasting in the schools of Lombardy. Like those of the rest of Italy they became imbued with the principles of the Caracci, and the later painters of Lombardy are feebly eclectic or coldly academic.

Of the *Neapolitan school* the earliest painter was Tommaso de' Stefani, a contemporary of Cimabue; and it can trace the succession down to the present day; but among them are very few great names. Of the 15th century the chief is Antonio Solario, called Lo Zingaro, a scholar of Lippo Dalmasio of Bologna, but who also studied under Gentile da Fabriano at Rome, and indeed in most of the cities of Italy, and whose numerous scholars formed what is called the school of Zingaro. His most celebrated work was a fresco in the choir of S. Severino, which represented in several compartments the principal events in the life of S. Benedict, and which, according to Lanzi, contained an incredible variety of figures. Antonello da Messina is also claimed by the Neapolitans; but from having practised his art at Venice until his death is usually placed among Venetian painters. Andrea Sabbatini da Salerno, whose style was formed on that of the Roman painters, and especially of Perugino and Raffaelle, is the greatest name of the 16th century. Of the 17th century the great masters are Giuseppe Ribera, called Lo Spagnoletto (b. 1592, d. 1656)—claimed by the Neapolitans from having practised in Naples, though a Spaniard by birth, and Salvator Rosa (b. 1615, d. 1673). Both of these painters owed much of their daring exaggeration and coarseness of style to the example of Caravaggio, the founder of the so-called 'Naturalisti.' The Spaniard had considerable native vigour, and he shrank from the representation of no scene however horrible. His best pictures are in Naples, and among them are a 'Martyrdom of S. Januarius,' in the Royal Chapel, and a S. Jerome in the church of the Trinity. Several of his pictures are in Spain, and among them are 'Ixion on the Wheel,' in the palace of the Buon Retiro, at Madrid. Salvator Rosa possessed more varied powers; but he was a man of irregular life, and something of his character is reflected in his works. His landscapes (often wild scenes in the Apennines) and his battle-pieces are the most prized of his productions, and are superior to his historical pictures.

Salvator had many followers, but, as in the other schools, the Neapolitan painters fell in due course under the influence of the dominant eclecticism, and ceased to have any distinctive character. The last Neapolitan painter who requires mention is Luca Giordano, called from his swiftness of execution Fa Presto (b. 1632, d. 1705). He was a man of great ability, but his facility of invention and execution, and the readiness with which he could imitate different styles, led him to a slightness of manner which was fatal to greatness. Lanzi gives particulars of numerous later painters, some of whom are highly praised by Neapolitan writers.

(Among the authorities on the Schools of Painting in Italy may be cited Vasari, 'Vite de' Pittori;' Baldinucci, 'Notizie de' Professori del Disegno;' Della Vale, 'Lettere Senesi;' Bellory 'Vite de' Pittori;' Zanetti, 'Della Pittura Veneziana;' Domenici, 'Vite dei Pittori Napolitani;' Lanzi, 'Storia Pittorica della Italia;' Fiorillo, 'Geschichte der Malerey;' Speth, 'Kunst in Italien;' Rumohr, 'Italienische Forschungen;' Kugler 'Handbook of Painting in Italy,' edited by Sir C. L. Eastlake, and Wornum, 'Epochs of Painting.' The rise and progress of Italian pictorial design may be traced in the plates of D'Agincourt's 'Hist. de l'Art pas les Monumens' (Peinture); but still better in Ramboux's splendid series of 300 folio plates of outline tracings from the original frescoes of Italy from 1200 to 1600.)

Northern School: Germany.—Painting in Germany can be traced back to the time of Charlemagne, but few examples are extant of painters' works of a date prior to the 15th century. Charlemagne was a munificent patron of art. The dome of the cathedral erected by him at Aix-la-Chapelle he caused to be covered with mosaics representing Christ enthroned, with the four-and-twenty elders worshipping. The walls of his palaces glittered with representations of his own victorious, and other famous fields of battle; his oratories with sacred subjects, or legends of the saints; and miniatori exerted their best skill in illuminating manuscripts for his service. Of the paintings and mosaics no vestiges remain; but illuminated manuscripts of the period show that a considerable amount of imitative skill was reached, and in the scrolls and arabesque ornamentations not a little fancy, though the human face and form are as meagre and uncouth as in wholly Byzantine work. The Byzantine influence is, however, still more evident in German work of the 10th and 11th centuries, a consequence perhaps of the marriage of Otho II. (978-983) with the Greek princess Theophania having given the German artists access to the technical skill of the Byzantines. From the middle of the 12th and in the beginning of the 13th centuries visible signs of new life in art began to show themselves. Ecclesiastical art took a wider scope; more artistic individuality was displayed; the drawing of the figure was improved, and expression was studied. The miniature painters especially made a marked advance, and many excellent examples of their work remain. In the 'Parcival' of Wolfram von Eschenbach, who lived early in the 13th century, the painters of Cologne and Maestricht are especially mentioned; and the series of compartments on the ceiling of the former monastery of Brauweiler, near Cologne, of about 1200, representing the 'Triumph of Faith,' and the figures of the Apostles, one of which bears the date 1224, in the church of St. Ursula, in Cologne, are, with those of scriptural subjects on the wooden roof of St. Michael's Church, Hildisheim, of the beginning of the 13th century, probably the oldest German pictures extant. But a more important work is the extensive series of paintings on the choir and transept of Brunswick cathedral, which appear to be of about the middle of the 13th century; and the paintings of saints recently discovered in restoring the transept of Bamberg Cathedral. (Kugler and Waagen.) A school of very able artists seems to have existed at this time in Bohemia; but towards the close of the 14th century the German painters recovered the lead, those of the school of Cologne being the most distinguished. Meister Wilhelm is spoken of by a contemporary chronicler, in 1380, as the best master of his day. Pictures attributed to him are to be seen in St. Castor, at Coblenz; some remarkably fine ones, formerly in the church of Sta. Clara, and now in the Cathedral of Cologne; in Cologne Museum; and in the Berlin Museum. The great altar-piece, formerly in the chapel of the town-hall, now in the cathedral of Cologne, is supposed to have been painted by Stephan Lothener, or as he was called, Meister Stephan, who died in 1451. The richness of the colouring, and the dignity and beauty of the Virgin, are most remarkable. Next to the schools of Cologne and Bohemia at this time ranks that of Nürnberg. A branch of the Cologne school appears about this time in Westphalia. Of this school the chief was a painter known as the Meister von Liesborn, whose great work was a large altar-piece in several compartments, painted for the second convent in Liesborn, but which was cut in pieces at the suspension of the convent by Napoleon in 1807; several of the pieces are lost; some are now, with other pictures of the master, in the National Gallery.

In the first half of the 15th century the German school departed little from the style it had previously followed, notwithstanding the great change introduced by the brothers Van Eyck into the practice of the painters of the Netherlands, with whom the German painters had always been closely associated. Traces of the influence of the technical improvements of the Van Eycks are indeed seen in the great work of Stephan Lothener: but the influence becomes much more palpable in the succeeding generation of painters, after the return of Martin Schongauer, and other Germans, from Brussels, where they had acquired, in the studio of Rogier Van der Weyden, the elder, a full initiation into the method of painting in oil as improved by the Van Eycks. It was, however, in the technics rather than in style that the influence of the Netherland masters was apparent. The old German nobleness of spirit was retained, but divested of some of the uncouthness of guise with which it had been disfigured; and its highest examples show great depth of thought and force of imagination, combined with singular faculty of invention and manipulative dexterity. The principal German painter of this period was Martin Schongauer, or, as he is commonly termed, Martin Schön (b. about 1420, d. 1488), and who was equally famous as a painter and an engraver. Genuine pictures by him are very scarce, those bearing his name being mostly old copies of his engravings. His most important painting is one of the Virgin in the church of St. Martin at Colmar. A small picture of the 'Death of the Virgin,' formerly in the collection of the King of Holland, an early work of Schongauer's, is in the National Gallery. Schongauer's pictures exhibit great knowledge of effect and a rich warm tone of colour. His fertility and vigour of imagination, and devotional feeling, are at least equally evident in his engravings: one of the most famous of these, 'St. Anthony tormented by Demons,' is said by Vasari to have been copied by Michel Angelo. Other noted but inferior German painters of this time were, Frederick Herlen (d. 1491); Thomas Burgkman; the elder Holbein; Bartholomew Zeitblom, in whom the style of Schongauer is seen sometimes carried to the verge of caricature, but sometimes raised to even a higher degree of earnest religious feeling; and Michael Wohlgemuth, of Nürnberg (b. 1434, d. 1539), a painter next to Schongauer in originality and power, though very unequal in his works, and the master of Albert Dürer.

The representative artist of the German school of the 16th century is Albert Dürer (b. at Nürnberg 1471, d. 1528): one of the great artists of modern times. In feeling for ideal beauty, Dürer is far inferior to his great Italian contemporaries; in colour he yields both to the Italian and Flemish painters. But in originality of conception, fertility of imagination, invention, dramatic power, depth of thought, force of expression, and accuracy of drawing, he ranks with the highest. He might, in painting, almost be called the founder of the romantic, as opposed to the classic school. Sometimes his exuberant, almost inexhaustible, fancy runs into grotesqueness, and his designs are too often overloaded with fantastic and insignificant details. In grace and refinement he is very deficient. But there is often a subtlety as well as boldness of thought, which is very impressive when his meaning is fully understood; and these qualities are even more evident in his engravings and woodcuts than in his paintings—as, for example, in the marvellous designs of 'Death and the Knight' and 'Melancholia.' The British Museum has a very rich collection of Dürer's engravings.

The earliest undoubted pictures of Dürer's are his portraits of his master, Wohlgemuth, and his own portrait in the Florence Gallery; among his latest and assuredly his finest works are the 'Apostles,' now in the Munich Collection. In 1506, Dürer visited Venice, but the Venetian school does not seem to have exercised a permanent influence over him, though a 'Virgin and Child,' with numerous kneeling figures, painted whilst there for the German Company, and some of the pictures painted shortly after his return to Germany, show that he appreciated the splendour of Venetian colour. [Dürer, Albert, in Biog. Div.]

Dürer formed a large school of imitators, many of whose works in the various European collections are attributed to their great master. Among the principal of his Nürnberg disciples are Hans von Kulmbach, or Hans Wagner (d. 1540), several of whose pictures are in the churches of Nürnberg, while others are in the Munich and other German galleries; Hans Schäufflein (d. 1540), an artist of considerable imitative skill; Henry Aldegraver; Bartel Beham (b. 1496, d. 1540); Albert Altdorfer, so called from the place of his birth (b. 1488, d. 1538), the best and most original of all Dürer's scholars: his chief work, 'The Victory of Alexander over Darius,' is in the Munich gallery; and George Pencz (b. 1500, d. 1550), who went to Italy and studied under Raffaelle, and, while retaining something of the very different manners of both his teachers, displayed enough of his own to secure a place among the original painters of his country.

Saxony about this time produced, in Louis Cranach (b. 1472, d. 1553), a painter of great and various original talent, but more realistic in tendency than Dürer. Cranach was court painter to the three electors, Frederic the Wise, John the Steadfast, and Frederic the Magnanimous. He accompanied the first to the Holy Land in 1493, and shared the prison of the last after the battle of Mühlberg in 1547. At a later period he was burgomaster of Wittenberg, and a friend of Luther, whose marriage with Catharine von Bora he contributed to bring about. One of his most celebrated pictures, the 'Crucifixion,' an altar-piece at Weimar, contains portraits of Luther, Melancthon, and Cranach himself. His pictures are well-coloured, but fanciful, and the features of his females most singular. Lucas Cranach, the son, was also a painter, but without much originality; several of his pictures are in the churches of Wittenberg. Matthew Grunewald (d. at Aschaffenburg after 1530) was, after Dürer, one of the best and most original German painters of the first half of the 16th century; another was Hans Burgkmair, chief of the Augsburg school (b. 1473, d. 1559), and famous for pictures of knightly pageants as well as for ecclesiastical subjects: his pictures are very numerous.

Hans Holbein, the younger (b. at Augsburg 1498, d. 1554), divides with Albert Dürer the rank of chief of the old German school; but, with invention scarcely if at all inferior to the great Nürnberg master, Holbein had less of the mediæval ecclesiastical spirit, and a less exuberant fancy. He is the type of old German realism: and, as in the case of Dürer, his characteristic genius in design is more fully and powerfully developed in his engravings and woodcuts than in his paintings. He had less subtlety of thought, but a purer sense of physical beauty than Dürer; was even a more prolific designer, and was possessed of much greater versatility; so that he could paint with equal readiness in oil, fresco, and distemper, and acquired celebrity alike as a painter of historical and religious subjects, portraits and miniatures; while his woodcuts, especially the series so rich in subject and ingenious in treatment entitled the 'Dance of Death,' were beyond parallel popular among his countrymen. His best paintings in Germany are in the cathedral and the gallery at Augsburg, in the museum and private collections of Basel, the altar-piece in the cathedral of Freiburg, and at Darmstadt. Holbein came from Basel to England in 1527, and remained here (with the exception of a few brief visits to the Continent) during the rest of his life, dying in the service of Henry VIII. In this country he executed comparatively few historical or biblical paintings, but a vast number of portraits (both oil paintings and chalk drawings), including the court, and most of the illustrious personages of the time. The royal collections at Windsor and Hampton Court contain a large number of the works executed by him whilst in England, but many are lost, including his two great pictures in tempera, 'The Triumph of Riches,' and 'The Triumph of Poverty,' painted for the company of German merchants in London, but which were presented by the company to Prince Henry of Wales in 1616, from which time all trace of them is lost. These were considered by Federigo Zucchero, who made a copy of them, to be equal to the works of Raffaelle; and the drawing in the British Museum shows that they must have been amongst the finest works of their class ever produced. One of his most noteworthy pictures is in the hall of the Barbers' Company, London; it is a composition representing eighteen members of that guild receiving a grant of privileges from Henry VIII. [Holbein, Hans, in Biog. Div.] Holbein had many followers, among whom the most celebrated were, Nicolas Manuel, a Swiss (b. 1484, d. 1531), and Martin Schaffner (flourished 1499-1535), whose chief works are in the cathedral of Ulm, the chapel of St. Maurice at Nürnberg, and the Munich gallery. From this time dates the decline of German art. Already its distinctive character was being lost in a general and feeble imitation of the Italian masters, the best painters being those who, like Johann Rothenhamner (b. at Munich 1564, d. 1623) and Adam Elzheimer (b. at Frankfort-on-the-Maine 1574, d. at Rome 1620), painted cabinet pictures, in a light graceful manner which has always found many admirers; their works consequently are in most public galleries, and many are in the private collections of this country.

The German painters of the 17th century were nearly all scholars of the Dutch and Flemish genre and landscape painters, or scholars and imitators of the Italian eclectics and naturalisti, while many of them resided permanently in the Netherlands or Italy. It will suffice, therefore, to mention Joachim von Sandrart (b. 1606, d. 1688), who painted every variety of subject in every variety of style, but who is now best known as the writer of a series of Lives of Painters, which has preserved much valuable information respecting his Italian contemporaries as well as his countrymen; Heinrich Schönfelds (b. 1609, d. 1675), equally versatile, prolific, clever, and without distinctive character as Sandrart; Heinrich Roos, much admired as a landscape painter; and his son Philip Roos, better known as Rosa di Tivoli (b. 1655, d. 1705).

In the 18th century, painting in Germany, as throughout Europe, was coldly academic and conventional, and devoid of all invention, originality, and feeling. Yet whilst thus merely imitative, the perception of harmony of colour, so characteristic of the painters regarded as models, was wholly wanting, and its absence seems scarcely to have been suspected. Even in the mechanism of the art there was marked degradation. Christian Rode (b. 1725, d. 1797), Johann Henry Tischbein (d. 1789), and Raphael Mengs (b. 1728, d. 1774), are among the few painters of the century whose names are still remembered. Mengs, extravagantly praised in his life-time, is now remembered as merely the type of a correct and accomplished academic painter—without a spark of genius or spontaneous feeling—the artistic law-giver of his age, and the author of some carefully considered, learned, and well-written treatises on painting. His pictures abound in the Continental galleries. Angelica Kaufmann (b. 1742, d. 1807), though German by birth, practised her art chiefly in England, and was one of the original members of the Royal Academy—ladies in the early days of that institution being allowed to append to their name the coveted distinction of R.A. All her pictures are respectable: their value may be estimated from the characteristic example in the National Gallery. Solomon Gessner (b. 1734, d. 1788) has made himself remembered as a painter by his celebrity as a poet; whilst Dietrich (b. 1712, d. 1774) and Chodowiecki (b. 1726, d. 1801) have acquired a certain reputation from the universality of their efforts and the commendations of their contemporaries. Elias Riedinger (b. 1695, d. 1767) claims mention as a clever painter and still more clever draftsman of animals and hunting-pieces; and Balthasar Denner (b. 1685, d. 1749) as a painter unrivalled for minuteness of detail, his hideous portraits having every freckle, wart, or wrinkle imitated with an accuracy that will bear examination with a magnifying glass.

The great revival of German painting in the early part of the present century, commenced by the exertions of a small band of zealous students then residing in Rome, with the result of the subsequent reaction against the excessive ecclesiasticism and mediævalism of the authors and supporters of the movement, can only be alluded to here. Some account of the movement, and of the principal actors in it, will be found under the names of Cornelius, Overbeck, Schadow, Veit, Schnorr, Lessing, &c., in the Biog. Div.

Painting in the Netherlands.—The divergence of the schools of the Netherlands from those of Germany dates from the beginning of the 15th century. The founders of the Flemish school were Hubert and Jan van Eyck (b. 1366, d. 1426, and b. 1400, d. 1445), who united the majestic simplicity of the old Christian type with a close imitation of external nature and a homely strength characteristic of their country. Their brother Lambert and sister Margaret were also artists. (Carton, 'Les Trois Frères van Eyck.') Hubert van Eyck may be said to have so far improved the method of painting in oil, as almost to be entitled to the honour, long accorded by mistake to his brother, of being its inventor. (See Eastlake's 'Materials for a History of Oil Painting,' where the question is fully investigated.) The great work of the brothers, it having been commenced by Hubert and finished by Jan, was the altar-piece in St. Bavo at Ghent, painted for Judocus van Vyt. It consisted of a centre picture of the Worship of the Lamb, surmounted by God the Father, the Virgin, and St. John, and flanked by folding shutters, all relating to the principal subject. The different parts of this painting, unquestionably one of the most remarkable productions of modern art, are now separated. The upper and middle portions remain at Ghent; the others are at Berlin. Michael Coxis executed a copy of it for Philip II., which is still more scattered. [Eyck, Hubert Van, in Biog. Div.] Two noble works by Hubert are the 'Triumph of the Church,' in the Museum of Madrid, and 'St. Jerome,' in the gallery at Naples, long attributed to Col-Antonio del Fiore. Jan van Eyck, though he has acquired a wider fame than his brother—in a great measure from his being regarded as "the inventor of oil-painting"—was a much less imaginative painter; but he carried the technics of painting far beyond any predecessor, and some of his pictures still remain in an almost perfect state of preservation—as, for example, that, dated 1434, of a man and woman (supposed to be portraits of himself and wife), in the National Gallery, which is one of the most admirable examples of his style.

The school of the Van Eycks was fertile in good painters, and their influence extended wherever painting was practised. One of the oldest of their scholars in the Netherlands was Justus Van Ghent; others of considerable celebrity were Dierick Steurbout, or Dierick Van Harlem, two altar-pieces by whom are in St. Peter's, Louvain, and some large paintings from the legend of the emperor Otho are in the Town Hall of the same city; and Hugo van der Goes, of Ghent, who is mentioned by Vasari, and some of whose pictures found their way to Italy. But the most distinguished of the scholars of Jan van Eyck, and one who by his numerous pupils did more than any other to extend the influence of the school, was Rogier van der Weyden, better known as Roger of Bruges (d. 1464). One of his finest works, a 'Last Judgment,' is in the hospital of Beaume; another, the 'Adoration of the Kings,' in the Pinacothek at Munich; and several admirable pictures by him are in the Berlin museum; others are in Antwerp, Brussels, Paris, and London. Chief among the scholars of Rogier was Hans Memling, perhaps the most eminent of the Netherlands' painters in all that respects refinement of feeling, beauty of form, and tenderness of expression. Some very beautiful works by him are preserved in St. John's Hospital, Bruges, of which he was an inmate about 1479. In the church of Our Lady at Dantzic is a large altar-piece, 'The Last Judgment,' a work of great extent and vigour, and probably the most important example of his pencil. Several of his pictures are at Munich. The traditions of the school were continued into the next century by Rogier van der Weyden the younger, Goswin van der Weyden, De Witte, Gerhart, Jan Gossaert, or Jan Mabuse, Jan Mostaert, and others, but towards the middle of the 16th century the Van Eyck influence had been nearly superseded.

Of the Antwerp painters of this time, the most famous is Quentin Massys, or Matsys, 'the Blacksmith' (b. 1460, d. 1530), one of the earliest painters of those homely subjects for which the artists of the Netherlands afterwards became so celebrated. His 'Misers,' of which there is a replica at Windsor Castle, is a well-known example of his style; but he also painted religious subjects, of which class the 'Virgin and Child' in the National Gallery is a favourable example. But his masterpiece, a 'Deposition from the Cross,' is in the Antwerp Museum. Luc Jacobez, or Lucas Van Leyden (b. 1494, d. 1533), was one of the ablest and most versatile artists of his time. The 'Last Judgment,' in the Town House of Leyden, is his most important work. But he appears to most advantage in his engravings, which are as numerous as his paintings are scarce.

The later works of Jan Mabuse (b. 1499, d. 1562), and the pictures of Jan Schoreel (b. 1495, d. 1562), Michael Coxis (b. 1497, d. 1592), Martin van Neen, or Martin Hemskerk (b. 1498, d. 1574), and Lambert Susterman, or L. Lombard (b. 1506, d. 1560), show that forced imitation of the Italians which characterises the transition from the old Flemish to the school of Brabant. This tendency is more strongly marked in Franz Floris (b. 1520, d. 1570), in the elder and younger Francks, in Bernhard van Orley (b. 1471, d. 1541), Heinrich Goltzius (b. 1588, d. 1617), still more famous as an engraver than a painter, Pieter de Witte, and Otho Venius (b. 1556, d. 1634), the master of Rubens. The works of these artists and their contemporaries—Abraham Blœmart (b. 1564, d. 1647), Cornelis van Harlem, Van Balen, and others—are deficient in independence and genuine feeling, though they interest us as being the groundwork of the school of Rubens. Among the portrait-painters of this time are several who acquired even more celebrity in this country than in their own. Of these, we may mention Sir Antony Moro (b. 1518, d. 1588), who, as painter to Philip of Spain, resided at the court of Mary, and painted portraits of the Queen, Lord Essex, Sir Henry Sidney, and other courtiers; Paul van Somer (b. 1576, d. 1624), who painted Lord Bacon and other of the distinguished men at the court of Elizabeth; Mark Gerard (d. 1635), the favourite painter of Elizabeth and her courtiers; Daniel Mytens, who painted James I. and Charles I.; and Cornelius Jansen, who succeeded Mytens as court painter.

The Netherlands witnessed, in the commencement of the 17th century, a revival of painting more striking than that effected by the Caracci. Peter Paul Rubens was born at Cologne in 1577, and died at Antwerp in 1640. After leaving the school of Otho Venius, he visited Italy, and studied particularly the works of Titian and Paul Veronese. His system of colour was based on that of the Venetians, and was only inferior to theirs. His forms are gross, but always full of life and vigour. His later pictures exhibit increased knowledge of effect, but the earlier are more attractive than those which were executed when the overwhelming number of commissions obliged him to employ unsparingly the pencil of his pupils. The 'Descent from the Cross,' in the cathedral of Antwerp, and its companion, are deservedly cited as among the best specimens of the master. His works may be studied in the greatest perfection in the museum and church of Antwerp, in the gallery of Vienna, and more especially at Munich. But almost every important Continental gallery contains paintings by him. Our own country contains a large number of his works. Among private collections, that at Blenheim is peculiarly rich in first-rate pictures by Rubens. The National Gallery possesses several of great excellence. Rubens is equally great in history, in landscape, and in portrait. To complain that the fire of his genius was not chastened as in the great Italian masters, is to wish that the artist had been a different individual from what he was formed to be. When we look at Rubens's works, their facility of execution, their energy, and their brilliancy hurry us beyond such considerations; when we think of them, we may regret that his forms are often ill-selected, that the brute animal vigour of his bacchanals is pushed to coarseness, and that the physical prevails so generally over the spiritual. [Rubens, in Biog. Div.]

The most celebrated of the pupils of Rubens was Antony Vandyck (b. 1599, d. 1641). At first he imitated closely the peculiarities of his master; but after his residence in Italy he adopted a more tranquil tone of feeling and soberer colour. His historical pictures have many excellent qualities, but they are not equal in their way to the numerous and admirable portraits, many of which were executed during a residence in England, and still remain in this country. [Vandyck, Antony, in Biog. Div.]

Of the other scholars of Rubens, few did more than imitate, and sometimes exaggerate, the outward characteristics of their leader, with the exception of Frans Snyders (b. 1579, d. 1657), who, as a painter of animals in vigorous action, has never been equalled. After Vandyck and Snyders, the best among Rubens's scholars were perhaps Jacob Jordaens (b. 1594, d. 1678), and Gaspar de Crayer (b. 1585, d. 1669).

In Holland, Michael Mirevelt (b. 1567, d. 1641) and Franz Hals (b. 1584, d. 1666) painted history and portraits, especially the latter, with great success. Barthol. van der Helst (b. 1613, d. 1670) approached very closely to Vandyck in colour. His finest work, the 'Festival given by the Burgher-guard of Amsterdam on the conclusion of the Treaty of Westphalia,' is in the museum of that city. Another excellent picture of smaller dimensions is in the Louvre.

The great master of the Dutch school, however, was Paul Rembrandt van Ryn (b. 1608, d. 1674). In his portraits and ideal heads we find the most wonderful truth and dignity; but his peculiar power consisted in a mastery of light and shade, which rendered the lowest subjects vehicles for high and poetical feeling. The depth and brilliancy thus produced seem hardly attainable by mere colour on a flat opaque surface; and when we look at his numerous etchings, we marvel still more how his needle on the copper has almost surpassed his pencil on the canvas. Conscious of his power to attain sublimity by light and shade alone, he seems often to have rejoiced in showing how that one charm could make us heedless of coarseness of conception and meanness of form. [Rembrandt, in Biog. Div.] Rembrandt's principal pupils and imitators were Gerbrand van den Eeckhout (b. 1621, d. 1674), Ferd. Bol (b. 1611, d. 1681), who excelled in portrait, Nicholas Maas (b. 1632, d. 1693), and Salomon Koning (b. 1609, d. about 1674), who in all his best qualities approached nearest to his master. Of another pupil, Gerard Dow, we shall speak immediately.

It is necessary just to mention Gerard Honthorst, called by the Italians Gherardo delle Notti (b. 1592, d. 1662), who imitated Caravaggio and the Italian "Naturalisti." His effects of torch and candle light are much celebrated. Gerard Lairesse (b. 1640, d. 1711) is best described as a Flemish imitator of Nicolas Poussin. Adrian van der Werff (b. 1659, d. 1722) has little to recommend him besides a finish and smoothness of surface, to which higher qualities are sacrificed: his human figures present the texture of ivory rather than of flesh, with much affectation and little genuine expression of passion or character.

We must now turn to those masters who are most distinguished in what is called "genre," a word for which it is difficult to find a substitute, and still more difficult to furnish a definition. The subject may be real or fictitious; but if the picture is on a small scale, and the object of the artist has been the expression of humour, or the prettiness of colour, or of light and shade,—if those qualities which are accessories in great works have been to him ends,—then it seems to come within the negative class, designated by the French word used above. It is the popular side, the every-day life of art, as contrasted with the epic grandeur of historical or the enthusiasm of devotional works.

Peter Breughel the elder (b. 1510, d. 1570) was called Boor-Breughel, from the subjects of many of his pictures, as his son, Peter Breughel the younger, obtained the name of Hell-Breughel, from the fantastic scenes which he pourtrayed; while a younger brother, Jan Breughel (b. 1568, d. 1625), is known as Velvet-Breughel, from the softness and delicacy of his handling: he painted animals and flowers even better than genre. The elder Teniers (b. 1582, d. 1649) delighted in subjects similar to the elder Breughel's; but as a painter he by no means equalled his son and pupil David Teniers (b. 1610, d. 1690) in those scenes of merry-making and peasant life for which he is so celebrated. Nothing can surpass the reality of the vulgar comfort with which the single figures sit and smoke, or the drunken gaiety of the larger assemblies, in the pictures of the younger Teniers. His colour is cool and his touch firm and vigorous. Sometimes he amused himself with imitating the works of masters of a different cast. In Adrian van Ostade (b. 1610, d. 1685) we have the same subjects treated in a warmer and more mellow tone, but perhaps with less individual truth and character, though with greater attention to general effect, than by Teniers. Isaac van Ostade painted fewer interiors, and followed his brother's style with less success. The humour of Adrian Brouwer (b. 1608, d. 1640), who is reported to have mixed deeply in the scenes which he painted, is of a broader cast. In Jan Steen (b. 1636, d. 1689) there are satirical touches and a genuine comic unity which remind one of Hogarth, though there is little of the Englishman's stern moral purpose. There is another department of genre, which bears the same relation to the drinking-bouts of Teniers or Brouwer that genteel comedy does to broad farce. In this Gerard Terburg and Gerard Dow stand pre-eminent. The former (b. 1608, d. 1681) threw into the scenes which he represented a delicacy of feeling and a sort of decorum which add greatly to the value of his execution and high finish. Of this kind are the celebrated Satin Gown, engraved by Wille; the Trumpeter at Munich; and the Cavalier and Lady in the Louvre. Gerard Dow (b. 1613, d. 1680) was the pupil of Rembrandt, from whom he gained a thorough knowledge of light and shade, and a feeling for general effect which preserved his elaborate execution from tediousness, while he secured by it a wonderful reality in the household scenes which he delighted to paint. In some of his pictures, as in that of the Dropsical Lady, there is even pathos. Gabriel Metzu (b. 1615, d. 1658) was the best imitator of Terburg. Franz Mieris, a scholar of Gerard Dow (b. 1635, d. 1681), equalled his master in fineness of finish, but not in genuine feeling. Caspar Netscher (b. 1639, d. 1684) and Eglon van der Neer (b. 1643, d. 1703) painted in the same style. The interiors of Peter van Hooghe (b. 1659, d. 1722) are remarkable for magical effects of light.

The great Italian painters Giorgione and Titian were admirable in landscape. Annibale Caracci and Domenichino have left excellent pictures in this department. But as if the ugliness of the country stimulated its natives to study all the aids which make an ordinary scene picturesque, it was in Flanders and in Holland that landscape painting was most cultivated. In the school of Van Eyck, the backgrounds are often elaborately imitated from nature: Joachim Patenier (b. 1487) and Herri de Bles (b. 1480, d. 1550) executed works in which the landscape claims an independent existence, and the figures have already become accessories. Jan Breughel, or "Velvet-Breughel," as has been mentioned, copied with wonderful minuteness all the variety of vegetation. Contemporary with Annibale Caracci there lived at Rome a Flemish artist, Paul Bril (b. 1554, d. 1626), who forms a sort of link between the landscape painters of the north and south.

In that kind of landscape the excellence of which consists in grandeur and the form of the large masses, Nicolas Poussin led the way. He was followed by Gaspar Duget, or Poussin (b. 1600, d. 1663), and Sebastian Bourdon (b. 1616, d. 1671). Claude Gelée was a native of Lorraine (b. 1600, d. 1682); he was first educated by A. Tassi, a scholar of Paul Bril, but nature, and nature alone, taught him to tinge his graceful forms of foliage and his rippling water with the cool pearly hue of morning, or the rich glow of an Italian evening. His pictures acquired in his lifetime the value which they have ever since maintained.

The style of Claude reacted on the Low Countries. Hermann Swanevelt (b. 1620, d. 1680) was his pupil: John Both (b. 1610, d. 1650) and Adam Pynacker (b. 1621, d. 1673) were painters of the same character. The Dutch landscape painters kept closer to Northern nature; such are the works of John van Goyen (b. 1596, d. 1656); generally low sea coasts, executed in a brown transparent tone. Anthony Waterloo (b. 1618, d. 1660) is better known by his admirable etchings than by his pictures.

The genius of Rembrandt exercised considerable influence over landscape; and he was admirably followed by his pupil Philip de Koninck (b. 1619, d. 1689), who in broad, open, flat landscapes, often equalled, and sometimes surpassed, Rembrandt himself. But the leaders of this particular school were Jacob Ruysdael (b. 1635, d. 1681) and his pupil Mindert Hobbema (b. 1611). The best works of these masters carry us into the depth of the forest, and convey that sort of lonely feeling which retired woodland scenery imparts. Albert Everdingen (b. 1621, d. 1675) gave his pictures more of the Norwegian character, and often painted water-falls and pine-forests.

We have said nothing of the pastoral side of landscape, in which Nicolas Berghem (b. 1624, d. 1683), Albert Cuyp (b. 1600), Carl du Jardin (b. 1640, d. 1678), and Adrian van der Velde (b. 1639, d. 1672), excelled. Philip Wouvermans (b. 1620, d. 1668) pursued a line peculiar almost to himself, or in which at least he has no rival. He executed battles, fairs, halts of cavalry, and all scenes in which horses occur, with truth and delicacy.

The most eminent marine painters were Bonaventura Peters (b. 1614, d. 1652), Ludolf Backhuysen (b. 1631, d. 1709), and William van der Velde (b. 1610, d. 1693). John Fyt (b. 1625, d. 1700), and John Weenix (b. 1644, d. 1719), painted animals; while De Heem, Van Schriek, Vromans, and others, devoted themselves with equal zeal to painting flowers, insects, &c., De Heem being, all things considered, the first in his line.

In the 18th century, painting was in Flanders and Holland as coldly imitative and conventional as elsewhere. Adrian and Pieter van der Werff, and Hendrick van Limborch, produced academically correct historical pictures; Jacob de Wit displayed extraordinary dexterity in making his canvases look like bronze relievi; the elder Van Mieris painted portraits and flowers; the younger wrought mythological subjects and poultry yards; the Van Nickelens, father and son, painted architecture and landscape; and Van Huysum flowers, with a truth and taste only inferior to De Heem. The schools of Belgium and Holland were somewhat late in arousing themselves from the slumber into which they had fallen in the last century; but at the present time painting is nowhere more earnestly and diligently, nor in some of its branches more successfully followed, than in Belgium.

(The most recent and comprehensive general survey of the history of the Northern schools, is Kugler's 'Handbook of Painting: German, Flemish, and Dutch Schools,' as recast by Waagen, Lond. 1860. See also Cavalcaselle and Crowe's 'Notices of the Early Flemish Painters;' Sandrart's 'Academia;' Descamps, 'La Vie des Peintres Flamands, Allemands, et Hollondais,' Par. 1753; Michiel's 'Histoire de la Peinture Flamande et Hollondaise,' Bruxelles, 1845-6; 'Hist. de l'Ecole Flamande,' Bruxelles, 1856; and Wornum's 'Epochs of Painting.')

The Spanish School of Painting cannot be carried back farther than the first half of the 15th century, though it is certain that miniatori were employed in illuminating manuscripts as early as the 10th and 11th centuries. The cradle of Spanish painting was Toledo. The Castilians borrowed something from the Byzantines, with whom they had much intercourse. But, as might be expected, the Flemish painters exercised a far more powerful influence in Spain. Two Flemish painters are especially singled out: Maestro Rogel (who was in Spain in 1445), who is identified by some with Rogier van der Weyden; and Juan Flamenco (1496), whom some, without much reason, suppose to be Hans Memling. Somewhat later, Titian, who spent some years in Spain in the service of Charles V., helped to mould the Spanish painters' principles of colour.

Luis de Vargas (b. 1502, d. 1568) was one of the first conspicuous Spanish painters. A thorough devotee, he helped to foster that ascetic tendency, and that entire subserviency to ecclesiastical canons, which formed so marked a feature in early Spanish painting. The works of Luis de Morales of Badajoz (b. about 1510, d. 1586) show some traces of early Flemish minuteness and hardness, with great power of expression, occasionally exaggerated: from the devotional character of his pictures, which are chiefly of the Saviour crowned with Thorns, or the Madonna Weeping, Morales has acquired from his countrymen the surname of "the Divine." Fernando Gallegos imitated Albert Dürer. Antonio del Rincon (b. 1446, d. 1500), Alonso Berruguete (b. 1480, d. 1562), Pedro Campaña, a Fleming by birth (b. 1503, d. 1580), Gaspar Becerra (b. 1520, d. 1570), Pablo de Cespedes (b. 1538, d. 1608), and Vincente Joannes of Valencia (b. 1523, d. 1579), who is regarded as the head of the school of Valencia, were the earlier Spanish masters of eminence who studied in Italy; the ablest, and certainly the most influential, being Berruguete, and next to him Gaspar Becerra.

The works of Rincon are rare: there is an altar-piece of his at Robledo de Chavela, not far from the Escurial. Campaña's Descent from the Cross, and the celebrated Gamba of Vargas are in the cathedral of Seville. The series of the Martyrdom of St. Stephen, by Joanes, is in the museum of Madrid. Alonso Sanchez Coello (d. 1590) and Juan Fernandez Navarrete el Mudo (b. 1526, d. 1579) painted respectively portraits and sacred subjects for Philip II. The colouring of Navarette is very fine, and resembles that of the Venetian school.

In the school of Seville, in the 17th century, the principal forerunners of Murillo were Juan Sanchez de Castro; Juan de las Roelas (b. 1558, d. 1625), who studied in Italy, and whose finest picture is perhaps the Death of St. Isidore, in the church of that saint at Seville; the two Herreras, and Francisco Zurbaran (b. 1598, d. 1662). The elder Herrera (b. 1576, d. 1656) is distinguished by vigour and boldness of execution. Zurbaran's great work of St. Thomas of Aquino, formerly in the Colegio de Santo Tomas, will bear comparison with the best pictures of any master. Bartolomé Esteban Murillo (b. 1618, d. 1682) has left early pictures at Seville which give little promise of his subsequent excellence. It was only after his return from Madrid in 1645 that he attained that freedom and power which characterise his best works. The name of Murillo is supposed by many in this country to stand highest in the Spanish school, but Diego Velasquez de Silva (b. 1599, d. 1660) was perhaps the greater man, though Murillo painted loftier as well as humbler subjects. The portraits of Velasquez are only equalled by those of Titian: his historical works in the Madrid Gallery, such as the Surrender of Breda, and his sketches of landscape in the same collection, are of great excellence. One of his most celebrated early pictures is the Water-carrier, now at Apsley House. His style, however, often runs into excess, bordering in its sternness on the violent contrasts of Caravaggio, but always avoiding his vulgarity.

Francesco Pacheco (b. 1571, d. 1654) was the founder of the school of Seville. His scholar, Alonso Cano of Granada (b. 1600, d. 1667) painted with simplicity and beauty, as well as vigour. Francisco Ribalta (b. 1551, d. 1628) is generally held to be the best master of the Valencian school. The altar-piece in the chapel of Magdalen College, Oxford, is probably by him. Claudio Coello (d. 1693) is one of the last Spanish masters who deserve notice. His picture in the Sacristy of the Escurial is a brilliant work.

The Spanish school can boast of several painters who may rank with the best of any other country. But Spanish painting was always limited in its scope, and was early exhausted. From the first it was eminently religious, and ascetic in its religion. It has been said that a nude figure does not probably occur in Spanish painting: and the most stringent rules were laid down by the ecclesiastical authorities for the treatment of the sacred and saintly personages introduced by artists on their canvases. The favourite subjects were connected with the mysteries of religion, the legends of the saints, and especially religious ecstacies. Though Murillo painted peasant boys with infinite relish, his greatest works are such as 'the Immaculate Conception,' or the 'Assumption.'

(Cean Bermudez, 'Diccionario Historico;' Stirling's 'Annals of the Artists of Spain;' Kugler's 'Hand-book: Spanish Schools,' ed. by Sir E. Head).

French School.—France, in the reign of Charlemagne and subsequently, had its miniature painters, and, as we see by the sculpture on its Gothic churches, always possessed a decided feeling for art. But the French can scarcely be said to have had a school of painting of their own until a comparatively late date. In the 16th century, Jean Cousin and the family of the Clovets were painters, who owed little to foreign teaching, but with these exceptions, the older French painters either studied and practised in Italy, or were mere imitators of Italian painters; while many Italians were either temporary or permanent residents in France. Among these were Lionardo da Vinci, Andrea del Sarto, Rosso, and Primaticcio, whom the zeal of Francis I. introduced into France. We find little independent existence of French painting before Simon Vouet (b. 1582, d. 1641), who studied the later Venetian painters, and Caravaggio: he was regarded as one of the first painters of his time, and was the master and model of the succeeding generation of French painters. His contemporary Nicolas Poussin (b. 1594, d. 1665) stamped a character on the art of his country which may be said to have lasted almost to our own days. His style is based in some degree on a confusion of the capabilities of sculpture and painting—statuesque forms, fine drawing, and the composition of a bas-relief clothed in unpleasing colour, though not wholly satisfactory to the eye, still combine to produce considerable effect; an effect however of a limited kind, analogous to that resulting from the classical correctness of Racine's tragedies, and without any life or spontaneity. Gaspar Poussin and Claude Lorraine, have been already named: they both learned their art in Rome and there practised it. The most famous of Vouet's scholars were Eustache Le Sueur (b. 1617, d. 1655), called the 'French Raffaelle,' a title sufficiently characteristic; and Charles Le Brun (b. 1619, d. 1690). The large pictures of Le Brun are very clever but disfigured by the affectation of the time of Louis XIV. Peter Mignard (b. 1610, d. 1695), another pupil in the same school, painted some good portraits. Antoine Watteau (b. 1684, d. 1721) is celebrated for the piquant grace of his courtly garden scenes and fêtes galantes. A clever imitator of his style was Nicolas Lancret (b. 1690, d. 1740), whose pictures, though wanting the *abandon*, are not seldom taken for those of Watteau. François Lemoine (b. 1688, d. 1737) was an imitator of Pietro da Cortona. Joseph Vernet (b. 1711, d. 1789) executed some very clever landscapes and sea-pieces, though for the most part disagreeable in colour. J. B. Greuze (b. 1726, d. 1805) excelled in the representation of scenes of domestic life, and in female portraiture; his style verges on the meretricious, but his pictures continue to increase in favour with the collectors, both of England and France. Under Coypel, Lemoine, Vien, Boucher, and Vanloo, Parisian art went on steadily deteriorating. It owes its resuscitation to the general mental excitement produced by the stirring wants of the revolution; but the special form which it assumed was due chiefly to the energy and tact of Jacques Louis David (b. 1748, d. 1825); though his pictures are in a thoroughly mistaken style. He endeavoured to carry out on a larger scale the "classical" principles of Poussin. It is impossible to deny his pictures the merit of fine drawing and a certain power; but disagreeable colour, exaggerated theatrical expression, and academic affectation mar the effect of their better qualities. His most eminent followers were Gérard, Gros, Girodet, Droling, Pujol, Guérin, and Géricault. Guérin carried the system of his master to the verge of caricature, and thus hastened the inevitable reaction. Gérard was a painter of considerable power, but marred by conventionalism, and utter want of feeling for colour. Some of his portraits are eminently characteristic; his huge transcripts of contemporary history are as eminently artificial.

Among the great leaders in the reaction, and the masters to whom the present position of French painting is mainly attributable, it must suffice to mention Jean Louis Géricault, Leopold Robert, Ary Scheffer, and Paul Delaroche, who have passed away; but Delacroix, Ingrez, Horace Vernet, and others, who still survive, have an equal title to rank among the pioneers of contemporary French art.

English School.—We have ample evidence that the English were among the earliest and warmest patrons of the art of the mediæval miniature painter; and manuscripts like the famous 'Durham Book' in the British Museum show that even in the 8th century British miniatori were at least equal to their brethren on the continent. In the 10th century English manuscripts were eagerly sought for abroad, and their mode of ornamentation was known as "English Work," (Opus Anglicanum): of this style and time is the beautiful Benedictional of St. Ethelwold, in the possession of the Duke of Devonshire. In the succeeding centuries the same excellence was maintained, and those who have devoted special attention to this branch of art remark that English miniatures are purer and richer in style, and freer from Byzantine characteristics than continental manuscripts of the same date. The art gradually passed out of use, but it is noteworthy that in the form of miniature portrait-painting which succeeded the decoration of missals and service books, English artists for some time maintained a decided superiority.

But of painting proper, though there is reason to believe that the paintings in mediæval churches and on the walls of palaces were frequently the work of native hands, there was no school founded in England till long after every other great European country. Henry VII. employed John Mabuse, Henry VIII. for many years retained Holbein, and after his death Sir Antony Moro as his court painter; and as we have already seen, succeeding monarchs usually had one or more distinguished foreign portrait-painters in their service. But it was long before an English painter was found to enter into competition with any of them even in this comparatively facile and always lucrative branch of art. In the reign of Elizabeth, two Englishmen, Nicholas Hilliard, and his pupil Isaac Oliver, acquired distinction as miniature painters. Hilliard imitated the manner of Holbein, but Oliver was more original, and was admitted to be, in his own line, one of the very best artists of his age. His son, Peter Oliver, was also a skilful miniature-painter.

Charles I. was an eager and an intelligent collector of pictures, and he invited to England Rubens, Vandyck, Hontherst, Gerbier, and many other painters of contemporary celebrity. His example was followed by his wealthier courtiers, and English as well as foreign painters soon became recipients of their patronage. The foreign painters represented every branch of the profession; but the Englishmen confined themselves almost exclusively to portraiture: Francis Barlow, an animal painter, being one of the few exceptions. But in portraiture English painters were strong. Robert Walker, who was patronised by Cromwell, painted a head nearly as well as Vandyck; while William Dobson (b. 1610, d. 1646) who was distinguished as "the English Tintoret," and succeeded Vandyck as sergeant-painter to the king, is in some of his best portraits little inferior to either of the great painters named in conjunction with him: his portraits are comparatively numerous. Other English portrait-painters were Nicholas Stone the younger (but best known by the cognomen of Old Stone), who studied in Italy, and was celebrated as a colourist; George Jameson, "the Scottish Vandyck," Richard Gibson the Dwarf, and Samuel Cooper (b. 1609, d. 1672) one of the greatest miniature-painters of any time.

Several of these lived to practise their art under Charles II., but neither in the reign of that monarch, nor in that of his successors did English painting find patronage, or indeed seek it. England was not wanting in painters, but among them not a single English name of eminence occurs till that of Hogarth. Lely and Verrio were the court painters to Charles II. and his brother; and to Lely succeeded Sir Godfrey Kneller as the royal and fashionable portrait-painter, while Laguerre followed Verrio as the manufacturer of those monstrous allegories with which it was the fashion to disfigure the staircases and ceilings of palaces. To these indeed Englishmen were the successors, but Jervas, Thornhill, and Hudson only served to carry a step lower the degradation of painting. Yet though painting in England was in a course of steady decline from the Restoration to the reign of George II., there were numerous English painters, some of whom it may be proper to mention. One of these was John Riley (b. 1646, d. 1691) court painter to William and Mary: he was perhaps the best imitator of the manner of Lely. Henry Cooke (b. 1642, d. 1700) is said to have studied under Salvator Rosa; he painted the chapel of New College, Oxford, and "restored" for William the cartoons of Raffaelle, without doing them much injury. Jonathan Richardson (b. 1665, d. 1745), who married the niece of Riley, and acquired that painter's traditions, was a respectable and prosperous portrait-painter; a great admirer of the works of the old masters, and of choice engravings, of which he formed an excellent collection; and the author of some very intelligent essays on the Theory of Painting, which are said to have contributed largely towards making Sir Joshua Reynolds a painter, and may still be read with profit. Charles Jervas, so extravagantly praised by Pope, was the leading portrait-painter of his day, but is now only noteworthy as a striking example of the influence of fashion. Sir James Thornhill was the first Englishman who met with extensive patronage in any other branch of painting than portraiture, and it was long before the example was followed. It will be enough to refer to Thornhill's paintings in the hall of Greenwich Hospital, and on the dome of St. Paul's as illustrations of his style. Thomas Hudson is only memorable as the master of Sir Joshua Reynolds.

The true regenerator of English art, and the first really great English painter, was William Hogarth (b. 1697, d. 1764), in his chosen line of moral satire one of the most original painters who ever lived. In Hogarth's day, and almost till the present time, it was usual to speak of him in the words of Walpole, as having "but slender merit as a painter." But his technical merits are better appreciated now, while as a humourist, a shrewd observer of contemporary life, and a master of ludicrous expression in face and form, he is acknowledged to be without equal. [Hogarth, William, in Biog. Div.]

The actual head of the British school of painting, however, was Sir Joshua Reynolds (b. 1723, d. 1792), the ablest and most intellectual portrait painter and the greatest colourist this country has produced, and not unworthy to rank with the best portrait painters and colourists of any country; it is only to be regretted that, owing to his imperfect technical training, so many of his works are already decayed or decaying. His historical paintings are only valuable as examples of his powerful colour and facile handling. Sir Joshua was the first president of the Royal Academy (founded in 1768), and in that capacity delivered the 'Discourses,' which have scarcely exerted a less powerful influence on English art than the productions of his pencil. [Reynolds, Sir Joshua, in Biog. Div.]

Thomas Gainsborough (b. 1727, d. 1788) was inferior to Reynolds as a painter of male portraits, but in expressing the lighter graces of the female face and form he was at least his equal. But his great original power lay in painting English cottage-doors, woodland landscapes, watering places, and similar simple rustic scenes—the poetry of homely English scenery—in which he is without a rival. His handling is, however, very loose, his sense of form deficient, and his drawing often indifferent; but he was an admirable colourist, and threw around almost everything he touched an indescribable charm. Richard Wilson (b. 1713, d. 1782) learned landscape painting in Italy, and aimed at a more "classic" style. He wanted many of the qualities which are required in the painter of landscapes of the class to which his belong, but he had a true painter's feeling, and produced many admirable works. George Romney (b. 1734, d. 1802) was the avowed rival of Reynolds in portrait, and he painted some historical pictures. Benjamin West (b. 1738, d. 1820), who succeeded Reynolds as president of the Royal Academy, was a native of Philadelphia, then a British colony, but, after studying some time in Italy, settled while still young in England, and enjoyed until the Regency the post of painter in ordinary to the king. West's was a fair representative of the cold academic style of historical painting then current; and, though there was more of vigour in the historical pictures of James Barry (b. 1741, d. 1806), there was no more real truth or greatness. Henry Fuseli (b. 1741, d. 1825) was by birth a Swiss, but resided in this country the larger part of his life, and was professor of painting in the Royal Academy; his mannerism and strange extravagance of conception and expression are notorious. John Opie (b. 1767, d. 1807), James Northcote (b. 1746, d. 1831), and John Singleton Copley (b. 1737, d. 1815), were among the other most prominent contemporary painters.

Succeeding these, and forming the connecting links between the painters of the time of Reynolds and those of our own day, are some artists whom we must be content to mention, referring for further information to the names in the Biographical Division. At the head of those we may place West's successor in the academic chair, Sir Thomas Lawrence (b. 1769, d. 1830), the most popular, though not the greatest of English portrait painters. Thomas Stothard (b. 1755, d. 1834), had a singularly graceful fancy, but is seen to most advantage in the small vignette engravings from his designs. Sir David Wilkie (b. 1785, d. 1841) in his earlier works showed inimitable skill as a painter of scenes of domestic life. William Etty (b. 1787, d. 1849) was a powerful colourist, and in his own peculiar line, though that line was an eminently conventional one, he was doubtless a master. Joseph Mallard William Turner (b. 1775, d. 1851), the most original, the most imaginative, and the most comprehensive of landscape painters, belongs to too recent a date for us to enter upon his merits or shortcomings here; nor is it necessary to do so, as he is spoken of at length in the Biographical Division. John Constable (b. 1776, d. 1837); Sir Augustus Wall Calcott (b. 1779, d. 1844); Benjamin Robert Haydon (b. 1786, d. 1846); William Collins (b. 1787, d. 1847); Charles Robert Leslie (b. 1794, d. 1859), and many more, might be quoted as illustrative of the variety, tendency, and character of English painting in the first half of the present century. But to do so without more space than we have now left, would answer no useful purpose. We must not, however, conclude without reference to the rise and growth of that peculiarly English branch of the art, water-colour painting. Of course, in speaking of it as an English art, it is not meant to be implied that there was anything new in the practice of employing water as the vehicle, or paper as the material on which the colours are laid. But the adoption of this distinct branch of art, and its special application, are due to our countrymen; and by them water-colour painting has been more practised, and carried farther, than by the painters of any other country. The founder of the English school of water-colour painting was Paul Sandby (b. 1725, d. 1809), an artist of versatile talents and great taste. Those to whom its extension is primarily due were John Cozens (d. 1794); Thomas Girtin (b. 1775, d. 1802), the friend and fellow-student of Turner, and Turner himself. Luke Clennell (b. 1781, d. 1839); Samuel Prout (b. 1783, d. 1852); David Cox and others, whose names will recur to the reader, aided materially in raising the art to its present high standing.

PAINTING, ENAMEL. [Enamel.]

PAINTING, HOUSE, is the art of painting the interior and exterior of dwellings and other buildings with a composition which shall preserve from decay, please the eye, and render the surfaces to which it is applied less liable to soil and easier to be cleaned. It is executed either in oil or distemper.

Oil Painting.—The principal tools employed are brushes made of hogs' bristles for large surfaces, and sash-tools made of finer hair for small work, as mouldings, window-bars, &c. After being used, they are kept in water to prevent their getting hard.

Concerning the pigments employed, white lead is used for white colour; it is also the basis of all ordinary colours. The colouring substances (*stainers*) in general use are earths, umber, ochre, Siena, Venetian red, purple, brown, &c.; the first three are sometimes burnt, a process which reddens and darkens them. Metallic compounds are red lead, vermilion, Prussian blue, chrome yellow, verdigris, Brunswick green, verditer, &c. Animal and vegetable colours are lakes, indigo, ivory black, and lampblack. All these require to be ground very fine in oil. This tedious and unwholesome process was formerly performed by hand, and by painters for their own use; but now the manufacturing chemists are enabled, by the application of machinery, to supply the articles cheaper than they can be prepared at home; and the painter, being relieved from this troublesome part of his business, will, if he aim at excellence in his profession, turn his attention to the higher branches of his art, and study the laws by which colours are related to each other, so as to be able to harmonise or contrast them as occasion may require.

The liquids in use are linseed oil (sometimes boiled with litharge to render it quickly-drying, and hence called *boiled oil*), and oil or spirits of turpentine, called *turps*. These are combined for use in various proportions according to circumstances. When the paint is required to bear a gloss, or is intended for outside work, most oil is used; and for black, chocolate colour, green, &c., outside, boiled oil alone, or with a very little turps, is best. For flatting, which has no gloss, turps alone is requisite. To all paint a little sugar of lead, or litharge (*dryers*) is added when required to dry quickly. It is important that all surfaces intended to be painted should be thoroughly dry, otherwise the paint will be liable to peel off.

With respect to mixing, the workman takes as much white lead as experience tells him is requisite, and a little oil or turps; and after these are mixed by stirring with a stiff knife, he adds dryers and a portion of one or more of the *stainers* above mentioned, according to the tint which he wishes to produce. After reducing the mass to the consistence of cream by the addition of turps or oil, the whole should be strained through a piece of canvas or muslin, when it is ready for use, and is termed by the workmen *colour*.

For the best work, the knots of yellow deal should be cut out to the depth of a quarter of an inch by the joiner, while the work is on the bench, and pieces of the same wood inserted in their places and glued in hand-tight only, for if compressed by a blow with a hammer they will afterwards swell and spoil the surface. For general purposes the knots are painted with red lead and size. When this is dry, they are smoothed with glass-paper, and the work is ready for *priming*, which is composed of red and white lead ground in and mixed with linseed oil only. When dry, the work is again rubbed down with glass-paper or pumice-stone, and all nail-holes, &c., are stopped with putty. The following coats contain about as much oil as turps, and are termed *second colour*, *third colour*, &c. The last coat previous to the finishing one is in all cases termed the *ground*, and is nearly the colour of the intended finish: except for black, green, and some other coarse dark colours, for which the ground is lead-colour, composed of white and black mixed together.

The repainting of old work is the same as new, with the omission of the knotting and priming.

Stone-work, stucco, &c., are treated the same as wood. It is the general practice to repeat the coats, allowing sufficient time between each to dry, till the work ceases to absorb, which is known by the absence of dull spots and patches. It is also the practice to omit turps in mixing *colour* for work which is expected to absorb much. As to *graining*, the methods, tools, and materials adopted in this art vary with almost every workman, and it would be useless to attempt to describe in writing the processes which are so dependent on the artist's taste. It may suffice to state that the work having received a ground in oil of the predominating colour of the material to be imitated, the grain of wood is generally represented by semi-transparent colours mixed in beer. The subsequent varnishing fixes the colours, imparts a gloss, and defends the work from the weather.

Distemper Painting.—The brushes for large surfaces differ from those used in oil: they are wider and flatter, and are termed distemper-brushes; but the tools for small work are similar. Whiting takes the same place in this branch that white lead holds in oil; the colouring substances are similar, but ground in water; and the fluids are water and melted size.

The whiting having been reduced to a stiff paste with water in which alum has been dissolved, the colouring matter is added, and the whole thinned with warm size. It must then stand till it gets cold, and it is not fit for use unless it *chills*, or forms a slight jelly. It is best to strain it after it has *chilled*, as the colouring substances will sometimes sink. Before applying this, the work must be cleaned; for if there remains any substance which the fresh applied colour will soften and mix with, the work will not present a uniform appearance, but will be cloudy. The best work is painted first in oil, then flatted, and finished in distemper; but seldom more than one coat of distemper can be applied with advantage, for which reason care should be taken to cover every part equally, and particularly that the brush touch no part that is once dry; for this last reason several men are employed together, that the whole of any surface (as a ceiling) may be covered before any part has time to dry.

It is a generally received opinion among painters that white lead is the best material for painting work of all descriptions, with a view to its preservation, and they affirm that black paint is useless in that respect. Now, presuming that the durability of paint depends on the insolubility of the materials used in its composition, we might infer that black, which is composed of one of the most imperishable bodies known, namely carbon, in the state of lampblack, is more durable than white, which is made of carbonate of lead, a substance slightly soluble in water: and the following facts confirm this. To be able to judge fairly, we must have black and white of the same age equally exposed, and on the same material. These conditions are all fulfilled on finger-posts and other public notices exposed by the highways and on wooden grave-rails in country churchyards, which are almost invariably painted and written either black and white or white and black. Those with black grounds and white letters may often be seen with merely the illegible remains of the inscriptions while the ground is quite perfect. But the black writing frequently remains not merely till the white ground is washed away, but often till the surface of the wood, except where it is occupied by the letters, is decomposed to the depth of more than a sixteenth of an inch, actually leaving the inscription in relief.

A more important circumstance connected with the use of white lead, however, is the extremely deleterious nature of this substance. House painters are much affected in their health in consequence. Zinc white has been introduced, and largely recommended, as a substitute for white lead; but the latter substance seems to possess qualities which enable it to beat down all opposition. Kuhlmann has recommended the adoption of sulphate of barytes. He declares that it is better than either white lead or oxide of zinc, more durable, and less injurious. It may be made either into dry cakes like white lead, or still better as a paste. Kuhlmann communicated a paper on this subject to the Academy of Sciences, at Paris, in 1858.

A patent process has been adopted for producing plain white polished surfaces in house painting. Carbonate of lead or zinc white is ground up with turpentine, partially dried, and mixed with copal body varnish; this paint is laid on, in many successive coatings, increasing the proportion of varnish at each stage. When dry, the surface is rubbed smooth with pumice dust or rotten stone, and polished with the hand. A kind of decorative painting is thus managed. Scrolls, flowers, or other devices are cut out of paper, and pinned to the wall or other surface; the surface is stippled with any suitable paint to produce a dead ground; when the stippling is dry, the paper is removed, and the ornament is left in high and light relief. In another method, the device is painted with a solution of sugar, starch, gelatine, and gum; the whole surface is then stippled over; and when dry, the stipple is washed off from the gelatinised surface.

Concerning painter's colours, it may here be stated that a manufactory was established at Battersea a few years ago, for making such colours by galvanic agency. During galvanic action, chemical decomposition always takes place in the cells; and by a careful choice of the liquids employed, sedimentary deposits of mineral colouring substances may be obtained. Practically, very brilliant colours were obtained, and sold in cakes; but the profits were not sufficient to render the speculation a permanent one. Another adventure has been that of obtaining a base for pigments from serpentine and other rocks containing silicates of magnesia and iron, by the action of certain acids; the bases thus obtained are mostly yellow, blue, and green. For the most part, however, painters are supplied with colours prepared by methods long practised.

The extent of this trade may in some degree be shown by the fact that painter's colours to the value of nearly half a million sterling are yearly exported from this country.

PALÆOGRAPHY (from παλαιός, *old*, and γραφὴ, *writing*), comprehends the study of ancient writing from the earliest periods until the invention of printing in the 15th century, or rather until that art became common at the commencement of the 16th.

The earliest specimens of writing occur upon stone, metals, wood, baked clay, wax, linen, the bark and leaves of trees, and the prepared skins of quadrupeds, goats, sheep, and calves. Writings upon the first named substances come more properly under the title of INSCRIPTIONS; those upon the bark of trees are fully treated of under the article PAPYRUS; it is therefore to some account of the principal characteristics of vellum or parchment manuscripts that the present notice is devoted.

In the earliest centuries we find much importance attached to the correct transcription of the works both of profane and theological authors, and as early as the 5th century, if not earlier, schools or associations of *scribes* were formed; who worked under definite and stringent rules. To a female scribe in one of these schools at Alexandria we are indebted for the famous copy of the Scriptures known as the 'Codex Alexandrinus,' written at the commencement of the 5th century, and now preserved in the British Museum. So great was the care taken to have correct copies of important works, that Jerome informs us that Pamphilus, the martyr, transcribed the works of Origen with his own hand; while distinguished men like Ambrose and Alcuin did not disdain the duty of comparing and revising the transcripts executed by the professional scribes. Baluzius cites decrees of the chapters against careless and bad copying, or transcriptions from vicious texts. In all the principal monasteries was a *scriptorium*, or writing-room, in which the *scriba*, *scriptor*, or scribe, could pursue his work in quiet, generally assisted by a *dictator*, who read aloud the text to be copied, the transcript was then gone over by a corrector, and afterwards handed over to the *miniator*, who added the ornamental capitals and artistic designs.

The word *parchment* is supposed to be derived from Pergamus, a city of Asia, in which the skins of sheep were largely prepared for manuscript purposes. *Vellum*, *velin*, prepared from the skin of the calf, *vitulus*, *veau*, from which it takes its name. The extreme whiteness and fineness of vellum may be taken as a sure sign of great antiquity. The finest vellum manuscripts are all prior to the 8th century.

Although a small cursive handwriting is occasionally met with even as far back as the 4th and 5th centuries, it was not until the close of the 8th that the *minuscule* writing became general. The broad capital letter in which the words are unbroken, and which has been designated as the *rustic*, is the prevailing character in manuscripts of the 4th and 5th centuries. The Vatican Virgil of the 4th century is a magnificent specimen of this style. The uncial and semi-uncial prevailed from the 6th to the 8th century. In the latter century fine minuscule Roman writing was not uncommon, and a fine example of this exists in the manuscript known as the Psalter of Charlemagne, in the Imperial Library at Vienna. Minuscule became general in Latin MSS. of the 9th, and Greek MSS. of the 10th century. The Latin MSS. of the 9th century are comparatively rare. They are for the most part written on fine thin vellum, in a small and very graceful character: the letters rather slanting to the right-hand. The manuscripts of the 10th century are more numerous than those of the preceding century, the letters are more upright, rounder, and fuller in shape, the vellum is commonly thicker and firmer. A magnificent specimen of the style of the 10th century, in the hand-writing of the famous St. Dunstan, abbot of Glastonbury, is preserved in the British Museum. It records a grant by King Eadred of the monastery of Reculver to the church of Canterbury, in the year 949. One is at first struck by observing that no trace of the ignorance which at this time darkened Europe, can be discovered in the numerous and exquisitely finished manuscripts of this century. But the fact may be partly accounted for by remembering the enormous dotations made to the religious orders, and their prosperity, in consequence of that very belief in the approaching end of the world, which degraded general society by the neglect of temporal interests to which it led. In the 11th century, owing probably to the general destitution, parchment was extremely rare, and it was in this century that the practice seems to have been most general of erasing ancient and so-called profane manuscripts in order to transcribe recent theological treatises upon the vellum thus acquired.

To manuscripts thus erased and again written upon, the name has been given of PALIMPSESTS, and to this word we refer the reader for a fuller description of such manuscripts. The handwriting of the 11th century bears a striking general resemblance to that of the 9th, the characters are small and closely written, and have a considerable slope. It seems probable that the small size of the writing may be in part accounted for by the difficulty of procuring parchment. The writing of the early part of the 12th century is not unlike that of the 10th, with the exception of the illuminated capitals, the peculiarities of which are described further on. The letters, however, particularly in English manuscripts, are larger and thicker. The vellum is mostly stout, and not so white. At the close of the century the beautiful and clear Roman writing was gradually becoming superseded by the introduction of an angular character, to which the term of modern Gothic has been applied. In the 13th century this Gothic character became universal. Even the round *o* was transformed into an elongated hexagonal. Abbreviations, hitherto rare and simple, became in this century numerous and abstruse. In addition to certain strongly defined peculiarities in illumination, of which we shall presently speak, the number and general use of abbreviations is, indeed, the most prominent palæographical distinction of the 13th century. In the 14th, the Gothic character still maintained its ascendancy; the letters, however, are generally broader and more open, and the abbreviations not quite so numerous as in the previous century. A great change is perceptible in the writing of the 15th century. Although still Gothic, it wants the massive and compact appearance of the two preceding centuries: the character is slighter and more open, and the heads and tails of the letters are thinner, weaker, and bended. Of the manuscripts of the 16th century it is almost unnecessary to speak. Owing to the introduction of printing, manuscripts had ceased to be written for the purposes of study, although occasionally, as well as in the two following centuries, executed as specimens of art or luxury. It should be remarked that the preceding sketch is confined to an attempt at delineating the appearance of the set hands of the various centuries. The cursive and epistolary styles are too capricious to be understood otherwise than by long and intimate acquaintance with the originals.

A method of distinguishing and deciding upon the various ages of MSS.—more easily acquired from description than the comparatively slight distinctions which mark the age of written documents, and which can only be acquired by careful study of originals—is afforded by the strong characteristic features displayed in the coloured and illuminated initial letters and ornaments so frequently found in MSS.

The first attempt at ornamentation seems to have been the use of *minium* or vermilion in marking the titles or commencement of manuscripts; and this is the origin of our word *miniature*, which first signified the rubricated letters, afterwards comprehended the whole separate branch of ornamentation of MSS., and now exclusively signifies a picture painted in the style necessarily adopted by the artists who worked on the small sheets of vellum, of which early books were composed.

In the most ancient volumes now remaining red letters were used for the purpose before mentioned, and in some cases also to mark words of particular importance—an example of which is afforded by the Alexandrian MS., and others of the 4th and 5th centuries. In these and the succeeding centuries the custom of writing in burnished gold and silver was extensively employed, remnants and records of which have descended to our times. The most ancient example is perhaps the *Codex Argenteus* of Ulphilas, written on purple vellum, at the close of the 4th century. The use of vellum stained of a rose or violet colour is peculiar to this early period, and lasted till the end of the 7th century—the efforts of the 8th and 9th centuries losing all the brilliancy and purity of the earlier specimens. In England purple MSS. were only introduced at the close of the 7th century.

Manuscripts written in letters of gold or silver on white vellum are chiefly confined to the 8th, 9th, and 10th centuries. Instances of its use in later times are on record, and in the 14th century instances are not seldom found; but at this period it can hardly be termed writing, being rather a laborious process of minute gilding.

On the works of the Byzantine schools, it would be beyond our present purpose to enlarge, as with slight variations, century after century, they followed old traditionary types. The influence, however, of Byzantine art has left strong and unmistakeable traces in all the works of the western nations, with which it is our present purpose to deal.

To the remotest of these nations the praise is due of having invented and developed an independent school of ornamentation, and one destined to become a formidable rival to the traditionary splendours of Eastern art. In Ireland, as far back as the 5th century, a style of art had been practised, which in the succeeding centuries attained a perfection almost incredible. In nearly complete isolation from the rest of the civilised world, having few opportunities of seeing and admiring the works of the great Greek artists, their method of ornamentation exhibits no artistic power in the higher sense of the word, but is remarkable for a fine harmony of colour, and a precision of technical execution little short of miraculous. The principal features of the style are an intricate and tortuous interlacing of narrow threads or ribands generally in symmetrical patterns, sometimes filling up a letter, sometimes extending over a whole page; now the introduction of a number of circular ornaments, now filled by marvellously delicate spiral lines proceeding from the centre, now by bolder wheel-like patterns of endless variety of design—to these may be added the use of numbers of birds and animals coiled up in endless and seemingly inextricable confusion, sometimes, as in the case of the Book of Kells, varied by the introduction of the human figure, and patterns formed of diagonal and straight lines, generally in squares or compartments, the idea of which some writers assert to have sprung from the remembrance of tesselated pavement.

Of manuscripts of this style the Book of Kells of the 7th century, now at Trinity College, Dublin, is the most important.

This peculiar method of design was early introduced into England by Irish missionaries, and a splendid specimen of its adaptation is preserved in the celebrated Durham Book, in the British Museum—which was executed at Lindisfarne at the commencement of the 8th century. In this may be traced at once a stronger influence of the Byzantine types; and though a most superb specimen of writing and decoration, it does not exhibit the same originality or fertility of imagination as the works of the Irish school. From England the new style passed quickly to the continent, and was soon adopted and largely used by the illuminators, and it is curious to notice in the manuscripts of the succeeding centuries, prolific in works of splendour and elegance, the admixture of the Celtic ornament with the remains of classic design.

A change, however, nearly as important, though not perhaps so original in conception as this of which we have treated, was introduced by the English illuminators of the 10th century. This consisted in the introduction of foliage. At first it was of an entirely rudimentary character, and exhibited none of the botanical skill or study of nature, so closely observed in later times. It was, in fact, the reflex of the bold and original ornamentation introduced by the architects of the period, and the styles of this and the two succeeding centuries were little more than adaptations to book decoration of the ornaments and mouldings of the great architectural works of the time. It was, however, a great advance on the semi-barbaric style of the Irish, or effete classicism of the continental works. Stalkless, thick-looking leaves spring from between and twine round the parallel bars of gold in borders or the curves of letters, coloured in every variety of tint, and mixing now and then with the interlacings and heads of animals, still retained from Hibernian designs. A most magnificent specimen of this peculiar style, to which on the continent the exclusive title of "*opus Anglicum*" was given, is the Benedictional of St. Ethelwold, now in the possession of the Duke of Devonshire. This manuscript was executed at Winchester (the great school of the arts in England) at the close of the 10th century. In the succeeding century the style was more developed, the forms and curves of the leaves were more freely drawn, with corresponding increase of knowledge and power in the figures and animals now freely introduced again, evident reproductions of the fantastic carvings of the architecture of the period. In the 12th century this foliation culminated in most luxuriant and fantastic conventionalism, and works of this period are perhaps as magnificent and splendid as any that any age has produced. The initial letters are very prominent and elaborate, and exhibit great elegance in the curves of the branches which support their luxuriant foliage. A very great advance too is visible in the drawing of the figures, and particularly of the drapery, which instead of the fluttering and restless timidity of the preceding centuries, falls in broadly marked masses, and indicates form in a highly artistic manner. These remarks chiefly apply to art in England, as there design was more original and exhibited less of the influence of the decadence of Byzantine art.

But a re-action from the strained conventionalism of this took place in the succeeding century, and men's minds were directed to a more careful study of nature for their guide; and to this study of nature, the groundwork of all that is beautiful and true, may be traced the wonderful advance visible in all the works of art of this great epoch, and of which its architecture exhibits such glorious memorials. Heretofore, the artists had drawn their foliage without study of the real nature of its growth, now they let themselves be guided by nature alone, and began the new era by using as the basis of their ornament the leaf springing from the bud. This is the principal feature in all the initial letters of this period, which now also become especially attractive from the use of burnished gold, scarlet, and blue. In the miniatures of manuscripts gold backgrounds are constantly employed, more especially in French work, the English artists confining themselves to a lower tone of colour, and employing backgrounds of colour relieved by small powdered patterns, differing considerably from the style we notice in the next century. In the 14th century the gold and plain back-grounds give way to rich patterns of diaper and chequer work, and the heavy mass of burnished gold is divided into minute patterns or entirely superseded by variegated colour. In this century too the bud expands into the leaf and the ornamentation of a letter, instead of being confined to one or two sprays of foliage, spreads out and encompasses the page in a glittering circle of golden leaflets, or by what we may term ornamental brackets, less massive but more elegant than the ornament of the 12th century; and rendering this the most easily distinguished, as well as the most attractive of all the various styles of illumination. In the 15th century sprang forth the flower, and very beautiful though gaudy was the result; and at the same time too, the progress of the art of painting caused the illuminators to depart in their works from their hitherto strictly symbolic character, and to aim at the direct representation of nature. The introduction of backgrounds of pure landscape in the miniatures is as nearly as possible coincident with the commencement of the century, and from this time the pictorial representations completly supersede in importance the mere ornamental portion of an illuminated page. As a consequence, the ornamented borders became gradually used as a mere framework for the miniature; and the beautiful ornament of the 14th century, by the introduction first of diagonal bands of gold and other patterns behind its foliage, and afterwards of solid grounds of colour, was degraded in time to the gaudy and meretricious style of the 16th century. The illuminations of that period are chiefly known by the use of sprays of flowers and fruit on delicate scroll work, relieved from the solid border by exquisitely executed shading—the lights heightened with gold, and to ordinary eyes presenting an appearance more attractive than the works of any preceding century.

We cannot in the limited space of this article do more than hint at the importance of the study of costume of different periods, as furnishing another very strong corroborative test of the age of manuscripts in which illuminations occur; nor, interesting though it be, can we treat of the purely artistic portion of the subject, as our present object is solely the palæographic portion of the inquiry. We will, therefore, at once sum up briefly, and in a manner easily remembered, the great lines of demarcation which separate the different epochs. This we will do, taking the centuries in triplets.

Of the first three centuries we can say nothing. In the 4th, 5th, and 6th we find little ornamentation beyond the rubricated or gilded letters of the actual text. The 7th, 8th, and 9th, witnessed the perfection and adoption of the Hibernian style. The 10th, 11th, and 12th, the introduction and use of architectural forms. The 13th, 14th, and 15th, the growth of foliage under carefully studied natural laws; the 13th century being the age of the bud, the 14th of the leaf, the 15th of the flower; and in the miniatures, the 13th the age of gold, the 14th, of diaper, the 15th the commencement of realistic painting. Of the next century we need say little, as manuscripts formed no longer the bulk of literature, but were mere costly appendages of luxury and taste.

The broad outlines we have here given are of course open to many exceptions, as the artists of different countries worked under different influences; indeed, to Italian works they can hardly be said to apply at all, as that nation infused a new life of its own into the Byzantine style in a more gradual manner than the sudden and independent changes of the western nations.

Throughout the whole of the dark and middle ages the value attached to the possession of manuscripts, and the activity shown in multiplying them, are very remarkable. Silvestre tells us that long previous to the 12th century, the most active zeal was displayed in search after ancient texts, even of profane authors. "In the middle of the 9th, Lupus, abbot of Ferrières, earnestly requested from the Pope and the bishops of England and Ireland, the loan of manuscripts of ancient writers that copies might be made of them; and in 1040, Count Geoffrey of Anjou gave to the abbey of Notre Dame of Saintes, the tithe of the hides of the deer killed in his forests, to furnish a fund to bind the books of the monastery." (Silvestre, ed. Madden, is 311.) The same writer, *loc. cit.*, mentions also the veneration paid in the 15th century to the Florentine Pandects of the Laurentian library, a magnificent volume written in the 7th century, and esteemed the most valuable of the manuscripts of the Roman law. This manuscript was taken from Pisa by the Florentines in 1406, and after its deposition at Florence "was regarded with almost religious veneration, being shown only to the highest personages, with great ceremony, in the presence of the chief magistrate, accompanied by monks, bareheaded, and bearing lighted tapers."

The price of manuscripts in the middle ages is a subject full of interest, the data for determining which, although existing scattered throughout various manuscripts, has never been properly collected or discussed. A recent writer (Mr. Digby Wyatt, 'Art of Illuminating') furnishes "a most interesting contemporary illustration of the precise terms upon which noble patrons employed the best illuminators of the day (14th century)," in the shape of an extract from the fabric rolls of York Minster, 1346, in which a contract seems to have been entered into for writing a volume containing psalter, hymnal, and collectary, ornamented with illuminated letters in gold, azure, and vermilion, for about sixteen shillings. Such a price, however, far from indicating the cost of the works of the "best illuminators," could only have represented a manuscript of comparatively rough and coarse description. There is in the British Museum a 14th century bible, taken by the English at the battle of Poictiers, exactly ten years after the date of the contract quoted above. The volume is a large one, and contains a good many illuminated letters in addition to some miniatures and borders of a tolerably fair, although by no means superior kind. This volume, the spoil of war, William Montagu, earl of Salisbury, purchased at the time for one hundred marks (upwards of 62*l.*, representing about 360*l.* of our money), as a present to his countess, and it was arranged that at her death it should be sold by her executors for 40*l.* This is recorded in a contemporary entry at the commencement of the volume, so curious in its details that we give it entire: "Cest liure fust pris oue le Roy de Fraunce a la bataille de Peyters, et le bon Comte de Saresbirs William Montagu la achata pur cent mars et le dona a sa compaigne Elizabeth la bone Countesse qe dieux assoile. Et est continus de dedeius le Bible enter oue text et glose e le mestre de histoires, et incident tout en memes le volym. La quele lyure la dite Countesse assigna a ces executours de le vender pur xl liuers." Again, in the 15th century, a roughly executed volume of 219 leaves, now preserved in the British Museum, and containing the Book of Wisdom with gloss, the capitals in plain blue and red, is priced at lx shillings. A further insight into the price of such manuscripts is gained from the very curious memoranda occasionally met with of the price for which such books were pawned or set in pledge. There is a manuscript in the old royal collection, British Museum (7 E v), which was pawned by its possessor five different times, between the years 1483 and 1510, a fact showing not only the worth of manuscripts, but how readily a money value might be obtained for them. This manuscript is of the 14th century, roughly executed, and contains a treatise entitled 'Pupilla Oculi,' by John Borough, and a sacramentary. It will be seen from the entries, which we subjoin, that in 1483 he pawned it for 20*s.*; in 1485, for 16*s.*; 1488, for 26*s.* 8*d.*; in 1510, for 20*s.*, and again for 16*s.* 8*d.*, and it must be remembered that these sums cannot be supposed at the most to represent more than a moiety of the worth of the manuscript: "Cautio domini Johannis Corke, excepta in cista de Gylford, A.D. 1483, 5 die Maii, et jacet pro 20*s.* Renovatur cautio hec 24 Januarii, A.D. 1485, et jacet pro 16*s.* Cautio M. J. Corke, A.D. 1488, in cista de Wagon et Hosy, et habet unum supplementum, et est Albertus de Naturis 2°. fo. illorum, et jacet pro 26*s.* 8*d.* Renovatur hec cautio per manus Magistri Johannis Corke, A.D. 1510, 22 die mensis May, et nunc jacet pro 20*s.* Item eodem die renovatur per manus ejusdem magistri Corke et nunc jacet pro 16*s.* 8*d.*" These entries specifying the sums lent upon manuscripts, sometimes for the accommodation of the possessor, and sometimes apparently as security for safe return when borrowed for purposes of study or transcription, are highly curious.

PALÆSTRA (*παλαιστρα*), which properly means a school for wrestling (*παλαίειν*, "to wrestle," and *πάλη*, "wrestling"), was used in several different significations. The word first occurs in Herodotus (vi. 126, 128), who informs us that Clisthenes built at Sicyon a dromos and palæstra, both of which he calls by the general name of gymnasia. At Athens, however, it appears probable that the palæstræ and gymnasia were distinct places, and that the former were appropriated to the gymnastic exercises of the boys and youths (*παῖδες* and *μειράκια*), while the latter were intended for those of the men; it is certain, however, that the boys also exercised in the gymnasia. These palæstræ were called by the names either of their founders or of the teachers of the gymnastic exercises (*παιδοτρίβαι*). We accordingly read in Plato of the palæstra of Taureas, which appears to have been one of the most celebrated. (Plato, 'Charmid.,' c. i.; with Heindorf's 'Note.')

In most of the other cities of Greece the palæstra formed a part of the gymnasium. According to Müller ('Archäologie der Kunst,' § 292) it included the *στάδιον* (stadion); *ἐφηβεῖον* (ephebion, or exercise hall); *σφαιριστήριον* (sphæristerion, or hall for ball-play); *ἀποδυτήριον* (apodyterion, room for undressing); *ἐλαιοθέσιον*, or *ἀλειπτήριον* (elæothesion, aleipterion, room for anointing); *κονιστήριον* (konisterion, for rubbing with dust); *κολυμβήθρα* (columbethra, a swimming-bath); *ξυστοὶ* (xystoi, covered walks); *περιδρομίδές* (peridromides, open walks); in fact, every part of the gymnasium except the outer porticoes. It appears, however, more probable that the term palæstra was confined to the rooms which were appropriated to the exercises of the athletæ, who, it must be recollected, were persons who were especially trained for contending in the public games, and therefore needed a course of gymnastic exercises different from that which was usually pursued. That this view of the subject is correct, is shown by the statement of Pausanias, who informs us (vi. 21, s. 2), that in the gymnasium at Olympia there were palæstræ for the athletæ, and also by that of Plutarch, who says ('Symp.,' ii., Probl. 4) "that the place in which all the athletæ exercise is called a palæstra."

Among the Romans the terms palæstra and gymnasium are used as synonymous. Thus Vitruvius gives a description (v. 11) of a Greek gymnasium under the name of palæstra. In the Greek cities in Sicily and Italy there also appears to have been no distinction in use between the two words (Cic. in 'Verr.,' ii. 14; Polyb., xv., p. 716, c.: Casaubon); whence the Romans probably came to use them in common. [GYMNASIUM.] (Krause, 'Gymnastik und Agonistik der Hellenen;' Becker, 'Charicles,' v. 1.)

PALANQUIN (sometimes written *Palankeen*, and *Palkee*), a kind of covered litter carried, by means of poles, upon the shoulders of men, which forms the principal vehicle for personal transport in Hindustan, and varieties of the vehicle are used in other eastern countries. In Hindustan the palanquin is described by Captain Basil Hall, in his 'Fragments of Voyages and Travels,' third series, vol ii. chap. vi., as about six feet long by two and a half feet wide, and provided with conveniences which enable it to serve at night-time for a bed, and in the day-time for a parlour. A pole is attached to each end of the palanquin, near the top, to carry it by. As the poles, which rest upon the shoulders of the bearers, are not elastic like those of a sedan-chair, Captain Hall states that a palanquin has not the same unpleasant motion as that vehicle; and Bishop Heber also, who gives an account of dâk travelling in the 'Narrative of a Journey through the Upper Provinces of India,' published after his death, observes that "the motion is neither violent nor unpleasant," but that, being incessant, it is impossible to draw in a palanquin, and not very convenient to read, excepting a large print. Only four bearers can, in an ordinary palanquin, place their shoulders beneath the poles, two at each end; but in passing over difficult ground two others will occasionally bear part of the weight by thrusting a bamboo under the body of the palanquin; and in travelling there are two or more sets of bearers, who relieve each other by turns. While walking or running with their load, the bearers, who form a peculiar class among the Hindus, keep up an incessant noise, sometimes like grunting or groaning, and sometimes approaching the character of a song, or of wild vociferation.

The mode of conveyance is undoubtedly ancient. A conveyance of this sort was used by the Egyptians, as is shown by a representation found at Beni Hassan. In western Asia they are usually carried by camels; and one of a similar character is borne by an elephant, but this is usually called a *howdah*.

PALATINE COUNTIES. Three of the English counties, Chester, Lancaster, and Durham are counties palatine, by prescription. The county of Pembroke, in Wales, was also a county palatine, till the statute 27 Henry VIII., c. 26. The archbishop of York, previously to the reign of Elizabeth, claimed to be a count palatine within his possessions of Hexham and Hexhamshire, in Northumberland, and is so termed in some ancient statutes; this was put an end to by the stat. 14 Eliz., c. 13.

Counts palatine are of feudal origin; and a reference to their history will clearly explain the meaning of the title, and many of the incidents of these territorial dignities. Selden says, "the name was received here doubtless out of the use of the empire of France, and in the like notions as it had in that use" ('Titles of Honour,' part ii.). In the court of the ancient kings of France, before the time of Charlemagne, there was a high judicial officer, called the Comes Palatii, a kind of master of the household, whose functions nearly resembled those of the Præfectus Prætorio in the elder empire. This officer had supreme judicial authority in all causes that came to the king's immediate audience. ('Tit. of Hon.,' part ii., chap. 33.) When the seat of empire was transferred to France, this title and office still continued, but the normal dignity, as well as a degree of jurisdiction and power analagous to those of the ancient functionary, were also given to a different class of persons. When the sovereign chose to confer a peculiar mark of distinction upon the holder of a certain fief or province, he expressly granted to him the right to exercise the same rank, power, and jurisdiction within his fief or province as the comes palatii exercised in the palace. Hence he also obtained the name of comes palatii or palatinus, and by virtue of this grant he enjoyed within his territory a supreme and peculiar jurisdiction, having royalties, or jura imperii, by which he was distinguished from the ordinary comes, who had only an inferior and dependent authority within his district or county. This was the origin of the distinction between the Pfalzgraf and the Graf in Germany, and between the count palatine and the ordinary count or earl in England. Selden says that he had not observed the word "palatine" thus used in England until about the reign of Henry II.

In conformity with this view, the counts palatine of England had jura regalia within their counties, subject only to the general superiority of the Crown sovereign; or, as Bracton expresses it (lib. iii. cap. 8), "regalem habent potestatem in omnibus, salvo dominio Domino Regi sicut principi." They had each a Chancery and Court of Common Pleas; they appointed their judges and magistrates and law officers; they pardoned treasons, murders, and felonies; all writs and judicial proceedings issued and were carried on in their names; and the king's writs were of no force within their counties. Many of these powers, such as the appointment of judges and magistrates and the privilege of pardoning, were abolished by the stat. 27 Henry VIII. c. 24, which also provided that all writs and process in counties palatine should from that time bear the king's name. The statute, however, expressly stipulates that writs shall be always witnessed in the name of the count palatine.

The county of Chester is a county palatine by prescription, being commonly supposed to have been first given with regal jurisdiction by William I. to Hugh d'Avranches. ('Tit. of Hon.,' part ii.) It was annexed to the crown, by letters patent, in the reign of Henry III., and since that time it has always given the title of Earl of Chester to the eldest son of the sovereign, being preserved in the crown as a county palatine when there is no Prince of Wales.

Lancaster appears to have been first made a county palatine by Edward III., who, in the twenty-fifth year of his reign, in his patent of creation of Henry, the first duke, granted him the dignity of a count palatine, and afterwards, in the fiftieth year of his reign, granted the same dignity by letters patent to his son John, Duke of Lancaster. Henry IV. was Duke of Lancaster, by inheritance from his father John of Gaunt, at the time of his usurpation; but he avoided the union of the duchy with the crown by procuring an act of parliament, which declared that the duchy of Lancaster should remain with him and his heirs for ever, in the same manner as if he had never been king of England. Upon the attainder of his grandson Henry VI., soon after the accession of Edward IV., the duchy became forfeited to the crown, and an act of parliament passed to incorporate the county palatine with the duchy of Lancaster, and to vest the whole in Edward IV. and his heirs, kings of England, for ever. Another act of parliament passed in the reign of Henry VII., confirming the duchy to the king and his heirs for ever; and from that time to the present it has continually been united to the crown.

Durham, like Chester, is a county palatine by prescription; but it is probable that the palatine jurisdiction did not exist long, if at all, before the Norman Conquest. (Surtees's 'History of Durham,' Introd., p. 15.) "There is colour to think," says Selden ('Tit. of Hon.,' part ii. c. 8), "that the palatine jurisdiction began then in Bishop Walcher, whom king William I. made both episcopus and dux provinciæ, that he might frænare rebellionem gentis gladio, et reformare mores eloquio, as William of Malmesbury says." Durham continued as a county palatine in the hands of a subject till 1836, the bishop being prince palatine, and possessing jura regalia. By stat. 6 & 7 Will. IV., c. 19, palatine jurisdiction was transferred to the crown, subject to certain restrictions which have been removed by later statutes.

PALI. [SANSCRIT LANGUAGE AND LITERATURE.]

PALIMPSEST (*παλιμψηστος*, from *παλιν* again, and *ψάω* to cleanse or rub) is a term applied to a manuscript, from which the original text has been erased, in order to make room for a second subject; a process which was accomplished by rubbing it with pumice-stone or other similar substances till the traces of the original writing disappeared, and then smoothing it down with a roller or polisher. That this practice was adopted by the ancients, appears from a passage in Cicero's letter to the jurisconsult Trebatius, where he praises his friend for having been so economical as to write on a palimpsest, but says that he should like to know what those things could have been which were considered of less importance than his letter. ('Ad Familiares,' vii. 18.) Palimpsests are also mentioned by Plutarch and Catullus, but these appear to have been rather leaves of books, so prepared that one writing could easily be expunged and another substituted, and were frequently used by authors for correcting their works, as is evident from the satire of Catullus:—

> "Puto esse ego illi millia aut decem aut plura
> Perscripta: nec sic, ut fit, in palimpsesto
> Relata; chartæ regiæ, novi libri,
> Novi umbilici, lora rubra, membrana
> Directa plumbo, et pumice omnia æquata."
>
> CARMEN, xxii., l. 5 *et seq.*

It was not, however, till the 9th or 10th century that this practice became at all general, and then it was more frequently resorted to by the Latins than the Greeks. In the 11th century it appears to have been at its height. In the 13th and 14th centuries edicts forbidding it were issued in Germany; and it had not entirely ceased in the 15th century: as Knittel, in his account of the palimpsest manuscripts in the Augustan library at Wolfenbüttel, tells us that in the early times of the art printed books were sometimes worked off on vellum from which ancient writings had been erased, and instances particularly an edition of the Clementine Constitutions, printed by Nicolas Janson in 1476 upon parchment, which had undergone this process of obliteration to prepare it for the purpose.

The earliest observations on palimpsest manuscripts were made in France, in 1692, by M. Boivin, of the Bibliothèque du Roi, who discovered beneath the Greek text of St. Ephrem, written in the 14th century, a portion of the Greek Bible, in uncial letters of the 6th century. This was followed, in 1755, by a similar discovery made by F. A. Knittel in the Augustan library at Wolfenbüttel, of a palimpsest manuscript of the Origines of Isidorus, under which was a translation of the Epistle to the Romans, by Ulphilas, bishop of Gothland, who in the 4th century was known to have translated the whole of the Scriptures into the language of that country, and to have invented a new character, consisting of letters borrowed chiefly from the Greek for that purpose, but of whose labours only the four Gospels were previously known to exist in the *Codex Argenteus* at Upsala. In 1762, Knittel published, in 4to, the greater portion of the missing volume, which, although not identical with the *Codex Argenteus*, as originally supposed, proved to be a portion of a similar manuscript.

By far the greatest discoveries in the field of palimpsest manuscripts were, however, made by Cardinal Mai. In his researches in the Ambrosian library at Milan, of which he was keeper, he discovered several fragments of Cicero's orations; these comprised the orations against Clodius and Curio, that 'De Ære alieno Milonis,' not previously known, and the oration 'De Rege Ptolemæo.' These treasures had lain concealed for centuries under a Latin translation of the Acts of the Council of Chalcedon, and were adjudged by the discoverer to belong to the 4th century. In another manuscript he detected several fragments of the orations of Symmachus, who had previously been known only from his epistles; and the whole of the comedies of Plautus, including a fragment of the 'Vidularia,' a lost comedy, of which all that previously existed were twenty lines, preserved by Priscian and Nonius.

Being promoted to the librarianship of the Vatican, he discovered in that library the treatise of Cicero, 'De Republicâ,' of which nothing had been known, in modern times, beyond the fragments preserved in the writings of Macrobius, Lactantius, Augustin, Nonius, and others. This priceless manuscript came from the celebrated Abbey of St. Columbanus, in Bobio, in the Milanese territory, having been purchased by Pius V., who appears to have been acquainted with its value as a palimpsest; yet no attempt was made to decipher it till two and a half centuries later, when Cardinal Mai brought out his famous edition at Rome in 1821. This manuscript, which contains 300 pages, is in double columns, each consisting of fifteen lines. The writing is in fine, large, Roman uncials, the words not divided. It is clearly one of the earliest palimpsest MSS. yet discovered, and is referred by Cardinal Mai to the 2nd or 3rd century of our era. Above the treatise was a copy of St. Augustine's Commentary on the Psalms, in a handwriting earlier than that of the 10th century.

These researches of Cardinal Mai gave a new zest to the study of palimpsest writings, and shortly after Niebuhr examined several of the manuscripts in the library of the chapter at Verona, one of which was discovered by him to contain a palimpsest of some ancient jurisconsult, which he suggested to be the Institutions of Gaius, a conjecture which was verified by the Berlin Academy of Sciences, under whose auspices the first edition of this work appeared in 1820, scarcely a ninth of the whole book having been found illegible. This palimpsest is more particularly interesting in a palæographical point of view from having been twice rescribed. The uppermost of the three writings, comprising 26 Epistles of St. Jerome, is in the uncial character. As to the age of the original manuscript, Niebuhr, who is supported by Kopp, conjectures it to be anterior to the time of Justinian.

The greater number of the very ancient palimpsest manuscripts which are preserved in the Vatican, and in the Ambrosian Library at Milan, as well as those at Turin, in which remains of the classical authors have been found, were originally brought from the monastery of St. Columbanus at Bobio, founded by the famous Irish saint, and are inscribed 'Liber Sancti Columbani de Bobio.' Numerous examinations have lately been made of the Latin and Greek manuscripts at Paris, and many palimpsests have been discovered, but none containing texts of importance.

In the British Museum is a palimpsest of the Iliad, written on vellum, in fine, square, Greek uncials with accents and breathings, not later than the 6th century; it contains about 4000 lines, the uppermost text being Syriac, probably of the 9th century.

To another Syriac manuscript contained in the same library, we likewise owe the important addition to classical literature of portions of the annals of Gaius Granius Licinianus. In the year 1847, the authorities of the British Museum purchased from M. Pacho a number of Syriac manuscripts, and fragments of manuscripts, which had formerly belonged to the monastery of *S. Maria Deipara*, in Nitria (the valley of the lake of Nitron). Amongst these was one containing fragments of sermons of St. Chrysostom, written in Syriac, probably about the 9th century, or rather later. On examination, several leaves of this manuscript proved to be palimpsest; and closer research revealed the fact, that prior to these Syriac sermons, the vellum had already received two earlier texts. The most ancient of these texts written in an uncial character, probably of the 4th century, was found to contain portions of the Annals of Licinianus. These were edited in 1857 by Dr. Karl Pertz, under the title, 'Gai Grani Liciniani Annalium quæ supersunt, ex codice ter scripto Musei Britannici Londinensis.' In the following year the text, as furnished by Pertz, was more carefully re-edited by seven scholars of the University of Bonn, under the title, 'Grani Liciniani quæ supersunt emendatiora edidit Philologorum Bonnensium Heptas.' The later of the two texts appears to be a grammatical treatise written in a cursive hand of the 7th or 8th century. It is much to be regretted that the chemical agency applied to this palimpsest for the purpose of rendering it more easily read, though successful for the moment, has ultimately caused many of the originally faint traces of letters to become absolutely illegible. This should act as a warning of the extreme caution necessary in employing powerful re-agents in similar cases.

PALISADES are strong palings placed generally 6 or 9 inches apart, and pointed at their top to act as an obstacle in fortifications. They are generally placed in field fortifications at the bottom of the counterscarp of the ditch, or else projecting nearly horizontally from the top of the escarp. In permanent fortification the interior slope of the glacis and the traverses of the covered way are furnished with palisades to assist in the defence; here the openings between the timbers allow the defenders to fire through them. They are secured together about their middle by a horizontal timber termed a ribbon, and also at their lower ends by a strong beam sunk 3 or 4 feet in the ground. In permanent works the timbers are generally about 4 or 6 inches square, or triangular by cutting these across the diagonal. But in field-works the rough stems of young trees are often used.

PALL, or PALLIUM, a cloak or covering; more especially used for the ornamental article of dress granted by the pope to patriarchs and archbishops: it is made of white wool, in the form of a band three fingers broad, to surround the shoulders, having pendants a span in length before and behind, the ends ornamented with red crosses. The origin of the pall is obscure; but its use is of high antiquity. Tertullian, who lived at the beginning of the 3rd century, wrote a treatise 'De Pallio.'

Sleidan, in his commentaries 'De Statu Religionis et Reipublicæ, Carlo V., Cæsare,' 4to, Argent, 1555, lib. xiii., p. 210, describes the ceremony of making the pall. The price at which they are purchased from the pope, he adds, is considerable; nor is it lawful for an archbishop to use his predecessor's pall. If by exchange, or in any other way, a patriarch or metropolitan is removed to another church, although he had purchased a pallium before, he must still be at the charge of a new one. Before the receipt of his pall an archbishop cannot perform the functions of his office, even if he has been translated, nor can the archiepiscopal cross be borne before him.

The original grant of the pall from Pope Julius II. to Archbishop Warham is still preserved among the Cottonian manuscripts in the British Museum. The following is the form:—"Ad honorem dei omnipotentis, et beatæ Mariæ Virginis, et beatorum Apostolorum Petri et Pauli ac domini nostri Julii, pp. ij. et sanctæ Romanæ Ecclesiæ, necnon Cantuariensis Ecclesiæ tibi commissæ, tradimus tibi Pallium de corpore beati Petri sumptum, plenitudinis videlicet pontificalis Officii, ut utaris eo infra Ecclesiam tuam certis diebus qui exprimuntur in privilegiis ei ab apostolica Sede concessis. Aloisius."

In the east the pall is called *omophorion* (ὠμοφόριον), and has been used at least since the time of Chrysostom, who was charged with accusing three deacons of taking his omophorion. (Photii, 'Bibliotheca,' edit. Par. 1611, p. 55.) It is worn by all the Eastern bishops above the phenolion, or vestment, during the eucharist; and, as used by them, resembles the ancient pallium much more nearly than that worn by Western metropolitans, approaching nearer to the shape of a cope.

In England the term pall is applied to the covering thrown over the coffin at a funeral; and our poets have used it as synonymous with a mantle or cloak of a stately character. Milton says,—

> "Let gorgeous tragedy
> In scepter'd pall come sweeping by."

(Du Cange, *Glossar.*, v. 'Pallium;' Picart's *Religious Ceremonies*; Palmer, *Origines Liturgicæ*, 8vo., Oxf., 1832, pp. 317, 318.)

PALLADAMINE. [PALLADIUM.]

PALLADIUM (Pd). A rare metal, chiefly occurring as an alloy with platinum and iridium, but sometimes in the pure state. For its natural history, see PLATINUM, in NAT. HIST. DIV. To isolate it, the platinum ore is dissolved in nitrohydrochloric acid, chloride of ammonium is added to precipitate the platinum, and the palladium is then thrown down as cyanide from the filtered solution by the addition of cyanide of mercury: the white flocculent cyanide of palladium is then heated with sulphur to expel cyanogen, and the sulphur finally got rid of by well roasting. Brazilian gold usually contains five or six per cent. of palladium, and is therefore another source of this metal.

Palladium is hard, white, ductile, and tenacious. It readily fuses before the oxhydrogen blowpipe, and is volatile at the temperature of melted iridium. It is more oxidisable than silver, but is very slowly tarnished in the air. Its density is 11·8. It dissolves in zinc, but does not combine with that metal. It forms a crystalline alloy with tin, containing three equivalents of palladium to two of tin, and the resulting compound very much resembles the corresponding alloys of silver and copper with tin. Palladium is soluble in aqua regia, or in hot nitric acid, but is not easily acted upon by the other acids. It is readily distinguished from platinum, which it somewhat resembles in appearance, by being stained brown by a drop of solution of iodine.

The equivalent of palladium is 53·24.

Palladium and *oxygen* form two well-defined compounds, viz.:—

1. Protoxide of palladium . . . . . PdO
2. Binoxide of palladium . . . . . . PdO_2

According to Rané a *suboxide* (Pd_2O) is produced on heating the hydrated protoxide to incipient redness.

1. *Protoxide of palladium* is obtained as a black powder on heating nitrate of palladium to low redness. It has somewhat the appearance of black oxide of manganese, and loses its oxygen when heated to whiteness. It is precipitated as a dark brown *hydrate* (PdO, HO), on adding carbonate of potash or soda to a solution of a protosalt of palladium. The hydrate is soluble in caustic potash, and loses its water when moderately heated.

2. *Binoxide of palladium* is obtained as a yellowish brown hydrate (PdO_2, HO) on adding solution of caustic potash, or carbonate of potash, to the solid double bichloride of potassium and palladium. It is reduced to the anhydrous state by mere boiling with water and is then black.

Carbide of palladium. Palladium is very apt to absorb carbon when heated in contact with that substance, and is thereby rendered exceedingly brittle.

Sulphide of palladium (PdS). A blackish brown precipitate, formed on passing sulphuretted hydrogen through a solution of a protosalt of palladium. The metal itself also when heated with sulphur combines with incandescence, and forms a fusible gray lustrous mass.

Iodide of palladium (PdI) is a black precipitate formed on adding iodide of potassium to a solution of a protosalt of palladium. It is insoluble in water, alcohol, or ether, but is decomposed on heating with caustic potash.

Bromide of palladium much resembles the iodide.

Palladium and *chlorine* form two chlorides:—

1. Protochloride of palladium . . . . . $PdCl$
2. Bichloride of palladium . . . . . . $PdCl_2$

1. *Protochloride of palladium.* The metal dissolves slowly in hydrochloric acid with production of protochloride, or quickly in aqua regia with production of bichloride. On evaporating the solution of bichloride to dryness and gently heating, the protochloride remains. It is soluble in water, and may be obtained in brown hydrated crystals. With ammonia it forms a number of interesting bodies resembling those produced by acting upon protochloride of platinum with the same agent; one of them is the *chloride of palladamine* (NH_3Pd, Cl) or chloride of ammonium, in which an equivalent of hydrogen is replaced by one of palladium. The oxide of palladamine (NH_3Pd, O) is a powerful base.

2. *Bichloride of palladium* is formed when the metal is dissolved in aqua regia. On adding chloride of potassium a red crystalline precipitate of *chloropalladiate of potassium*, or double chloride of palladium and potassium is thrown down.

Cyanide of palladium ($PdCy$). Cyanogen has a greater affinity palladium than for any other metal. White, or slightly yellow coloured, flocks of cyanide of palladium are precipitated whenever a soluble cyanide is added to a palladium salt. Cyanide of palladium is soluble in solution of cyanide of potassium, forming a double salt, which crystallises in prisms containing (KCy, PdCy, 3 Aq).

Nitrate of palladium is formed by dissolving the metal in nitric acid. It is not very stable, but by careful manipulation may be obtained in rhomboidal prisms.

Sulphate of palladium (PdO, SO_3) may be produced by boiling the nitrate with sulphuric acid. It is very deliquescent.

Alloys of palladium. Steel alloyed with one per cent. of palladium is well adapted for making cutting instruments that require a perfectly smooth edge. Four parts copper and one palladium form a white ductile alloy. One part of palladium gives with six of gold an alloy that is nearly colourless.

Tests for palladium. The colour of the iodide, and the production of the cyanide under the circumstances indicated, are the chief tests for palladium. Protochloride of tin throws down a black precipitate soluble in hydrochloric acid with production of an intensely green solution.

PALLIUM. [Pall.]

PALM. [Weights and Measures.]

PALM-OIL. [Oils, Manufacture of.]

PALM-SUNDAY, the Sunday before Easter, so named because on that day boughs of palm-trees used to be carried in procession, in imitation of those which the Jews strewed in our Saviour's way when he went up to Jerusalem. It is still customary with our boys, in most parts of England, to go out and gather slips with the willow flowers or blossoms at this time; these are selected as representatives of the palm, because they are generally the only plants, at this season, easily to be come at, in which the power of vegetation can be discovered. Barnaby Googe, in his 'Popish Kingdome,' 4to, Lond., 1570 (a translation from Naogeorgus), alludes to the use of willow branches, at that time, instead of palm.

Stow, in his 'Survey of London,' tells us that "in the week before Easter had ye great showes made for the fetching in of *a twisted tree*, or *with*, as they termed it, out of the woods into the king's house, and the like into every man's house of honour or worship." This must also have been a substitute for the palm. An instance of the remote antiquity of this practice in England is afforded by the 'Domesday Survey,' under Shropshire, vol. i., p. 252, "Terra dimid. car. Unus reddit inde *fascem buxi in Die Palmarum.*"

These boughs or branches of palm, whatever they might be, underwent a regular blessing. (See the 'Missale ad Usum Ecclesiæ Sarisburiensis,' 4to, London, 1555.) In Roman Catholic churches branches of yew are carried and blessed on Palm-Sunday.

The Russians of the Greek Church have a very solemn procession on Palm-Sunday.

PALMIC ACID. [Ricinelaïdic Acid.]

PALMIN. [Ricinelaïdin.]

PALMITATE OF MYRICYL. [Bees-Wax; Palmitic Acid.]

PALMITIC ACID ($C_{32}H_{31}O_3$,HO). *Ethalic Acid. Cetylic Acid. Olidic Acid.*—An organic acid belonging to the family represented by acetic acid. It is found in the free state in palm oil; in combination in bees wax, spermaceti, and human fat, and may be artificially obtained by the action of hot alkalies upon ethal or oleic acid.

To prepare the acid from palm oil, the latter must be saponified by caustic soda or potash, and the soap decomposed by hydrochloric acid. The mixture of oleic and palmitic acids thus set at liberty must now be dissolved in alcohol and the alcoholic solution set aside to crystallise. The palmitic acid crystallises out whilst the oleic acid remains in solution; the latter acid is however only removed after several re-crystallisations.

Palmitic acid is a colourless, crystalline, inodorous and tasteless solid. It is insoluble in water, upon which it floats, but very soluble in boiling alcohol and ether. It fuses at 144° Fahr., and volatilises without residue at a high temperature. By long exposure to air at an elevated temperature it is said to lose carbon and hydrogen, and to be transformed into *palmitonic acid* ($C_{31}H_{31}O_4$) but this is doubtful.

Palmitic acid unites with bases forming salts, which have the general formula:

$$\left.\begin{matrix}C_{32}H_{31}O_2\\M\end{matrix}\right\}O_2$$

With the exception of the salts of the alkalies, all the palmitates are insoluble in water.

Palmitic acid also unites with glycerin, forming the following compounds:

Monopalmitin	$C_{38}H_{38}O_8$
Dipalmitin	$C_{70}H_{70}O_{12}$
Tetrapalmitin	$C_{134}H_{130}O_{16}$

Tetrapalmitin is said to be identical with the natural compound of palmitic acid with glycerin—*palmitin*, the formula of which is generally written $C_{70}H_{66}O_8$.

The following are some of the most important of the remaining compounds of palmitic acid.

Palmitic ether	$C_{32}H_{31}(C_4H_5)O_4$
Palmitate of cetyl, or cetin	$C_{32}H_{31}(C_{32}H_{33})O_4$
Palmitate of myricyl, or myricin	$C_{32}H_{31}(C_{60}H_{61})O_4$

PALMITIC ETHER. [Palmitic Acid.]

PALMITIC GROUP. A small family of organic compounds containing the radical *palmityl* or its derivatives. The following are the most important of these compounds. [Palmitic Series.]

Hydride of palmityl or cetylic aldehyde	$C_{32}H_{31}O_2$, H
Palmitone or ethalone	$C_{30}H_{31}$, $C_{32}H_{31}O_2$
Palmitic acid	$\left.\begin{matrix}C_{32}H_{31}O_2\\H\end{matrix}\right\}O_2$

PALMITIC SERIES. A division of organic bodies in Gerhard's system of classification, homologous with the acetic series of bodies. It is divided into two groups, namely

Palmitic group.	Oleic group.

The palmitic group is homologous with the formic and acetic groups, whilst the oleic group has its homologues in the acrylic and angelic groups.

PALMITIN. [Palmitic Acid.]

PALMITONE. [Palmitic Group.]

PALMITONIC ACID. [Palmitic Acid.]

PALMITYL. [Palmitic Group.]

PALSY. [Paralysis.]

PAN, a deity of the Greek mythology, whose country was Arcadia. He is said by Homer to be the son of Hermes by the daughter of Dryops; but other writers, while calling Hermes his father, give him a different mother; while some make him to have been of different descent on the side of father as well as mother. He was the tutelar god of the shepherds. Pan is sometimes represented with sprouting horns, a goat's beard, a goat's tail, and goat's feet, holding the syrinx, a kind of musical pipe, which he was said to have invented. But in older Greek art he is often without these animal appendages; as in the terminal statue in the British Museum. The satyrs are his attendants; and hence they are sometimes called Panes. In Greek art he is figured with nymphs and satyrs as well as alone. Pan is mentioned in the early mythi as having been present at the battle of the Titans, whom he assisted in routing by frightening them by a wild noise which he produced by blowing in a sea-shell. He was also said to have accompanied Bacchus to India, and that upon one occasion, by uttering a loud scream, which was repeated by the echoes, he scared away the enemy. From these incidents the expression "panic fear," meaning a terror produced by no obvious or sufficient cause, appears to have been derived. He is sometimes represented as the god of terror. Pan was worshipped at Athens and most other Greek cities. His worship was introduced into Italy at an early period, where he was identified with an earlier god, Inuus; and festivals, called Lupercalia, were instituted

in honour of Pan Lupercus, the protector of the flocks against wolves. According to Servius (note to Virgil's 'Eclogues,' ii. 31) Pan was also considered as the god of Nature, a personification of the universe, the word *pan* (πᾶν), in Greek, meaning "all," or "the whole," but this was a late notion.

PANATHENÆA (Παναθήναια), the greatest of the Athenian festivals, was celebrated in honour of Athena (Minerva) as the guardian deity of the city (Ἀθήνη πολιάς). It is said to have been instituted by Ericthonius, son of Hephæstus (Harpocrat., Παναθ.), and to have been called originally Athenæa (Ἀθήναια); but it obtained the name of Panathenæa in the time of Theseus, in consequence of his uniting into one state the different independent states into which Attica had been previously divided. (Paus., viii., 2, s. 1; Plut., 'Thes.,' c. 20; Thucyd., ii. 15.)

There were two Athenian festivals, which had the name of Panathenæa: one of which was called the Great Panathenæa (μεγάλα Παναθήναια), which was celebrated once in every five years with very great magnificence, and attracted spectators from all parts of Greece; and the other, the Less Panathenæa (μικρά Παναθήναια), which was celebrated every year in the Piræus. (Harpocrat., loc. cit.; Plato, 'De Rep.,' i. 1.) When the Greek writers speak simply of the festival of the Panathenæa, it is sometimes difficult to determine which of the two is alluded to; but when the Panathanæa is spoken of by itself, and there is nothing in the context to mark the contrary, the presumption is that the Great Panathenæa is meant; and it is thus spoken of by Herodotus (v. 56) and Demosthenes ('De Fals. Leg.,' p. 394).

The Great Panathenæa was celebrated on the 28th day of Hecatombæon (Proclus, quoted by Clinton, 'Fast. Hell.,' p. 325), the first of the Athenian months, which agrees with the account of Demosthenes ('C. Timocr.,' p. 708, 709), who places it after the 12th day of the month. There is considerable dispute as to the time in which the Less Panathenæa was celebrated. Meursius places its celebration in Thargelion, the eleventh of the Athenian months; but Petitus and Corsini, in Hecatombæon. Mr. Clinton, who has examined the subject at considerable length ('Fast. Hell.,' p. 332–335), supports the opinion of Meursius; and it does not appear improbable that the Less Panathenæa was celebrated in the same month as the Great, and was perhaps omitted in the year in which the great festival occurred. The celebration of the Great Panathenæa only lasted one day in the time of Hipparchus (Thucyd., vi. 56); but it was continued in later times for several days.

At both of the Panathenæa there were gymnastic games (Pind., 'Isthm.,' iv. 42; Pollux, viii. 93), among which the torch-race seems to have been very popular. There were also chariot and horse races. In the time of Socrates, there was introduced at the Less Panathenæa a torch-race on horseback. (Plato, 'De Rep.,' i. 1.) At the Great Panathenæa there was also a musical contest, and a recitation of the Homeric poems by rhapsodists. (Lycurg., 'C. Leocr.,' p. 209.) The victors in these contests were rewarded with vessels of sacred oil. ('Pind., 'Nem.,' x. 64, and Scholia; Schol. on 'Soph. Oed. Col.,' 698.)

The most celebrated part however of the Great Panathenaic festival was the solemn procession (πομπή), in which the Peplus (Πέπλος) or sacred robe of Athena was carried through the Ceramicus and other principal parts of the city to the Parthenon, and suspended before the statue of the goddess within. This Peplus was covered with embroidery (ποικίλματα, Plato, 'Euthyph.,' c. 6), on which was represented the Battle of the Gods and the Giants, especially the exploits of Zeus and Athena (Plato, loc. cit.; Eurip., 'Hecub.,' 468), and also the achievements of the heroes in the Attic mythology, whence Aristophanes speaks of "men worthy of this land and of the Peplus." ('Equit.,' 564.) The embroidery was worked by young virgins of the noblest families in Athens (called ἐργαστῖναι), of whom two were superintendents, with the name of Arrephoræ. When the festival was celebrated, the Peplus was brought down from the Acropolis, where it had been worked, and was suspended like a sail upon a ship (Paus., xxix. 1, s. 1), which was then drawn through the principal parts of the city. The procession which accompanied it consisted of persons of all ages and both sexes, of foreigners resident at Athens as well as of citizens. The old men carried olive branches in their hands, whence they were called Thallophori (Θαλλοφόροι), and the young men appeared with arms in their hands, at least in the time of Hipparchus. (Thucyd., vi. 56.) The young women carried baskets on their heads, whence they were called Canephori (κανηφόροι). The sacrifices were very numerous on this occasion. During the supremacy of Athens every subject state had to furnish an ox for the festival. (Schol. on Aristoph. 'Nub.,' 385.) It was a season of general joy; even prisoners were accustomed to be liberated, that they might take part in the general rejoicing. (Schol. on Demosth. 'Timocr.,' 184.) After the battle of Marathon, it was usual for the herald at the Great Panathenæa to pray for the good of the Platæans as well as of the Athenians. (Herod., vi. 111.)

The procession, which has been described above, formed the subject of the bas-reliefs which embellished the outside of the temple of the Parthenon, which are generally known by the name of the Panathenaic frieze. The blocks of marble of which this frieze was originally composed, were 3 feet 4 inches high, and they formed a connected series of 524 feet in length. A considerable portion of this frieze, which is one of the most splendid of the ancient works of art, is in the British Museum. [ELGIN MARBLES.]

A full and detailed account of this festival is given by Meursius, in a work on the subject, which is printed in the seventh volume of the 'Thesaurus' of Gronovius.

PANCAKE, a thin cake of batter fried or baked in a pan. The annual custom of frying pancakes (in turning or tossing which in the pan there was usually a good deal of pleasantry in the kitchen) is still retained in many families throughout the kingdom on Shrove Tuesday, and was formerly universal. The church bell which used to be rung on that day, to call the people together, in Roman Catholic times, for the purpose of confessing their sins, or shriving themselves, was called the pancake-bell, a name which it long retained.

According to Brand ('Popular Antiq.'), a kind of pancake feast preceding Lent was used in the Greek Church, from whence we probably have borrowed it, and pancakes are eaten at any time, though more generally on Shrove Tuesday. The Russes, Hakluyt says, begin their Lent always eight weeks before Easter. The first week they eat eggs, milk, cheese, and butter, and make great cheer with pancakes and such other things.

PANCHA-TANTRA. [PILPAY, in BIOG. DIV.]

PANDECT. [JUSTINIAN'S LEGISLATION.]

PANDUS. [MAHABHARATA.]

PANEGYRIC (from the Greek 'panegyricus,' πανηγυρικος λόγος) is a species of oration in praise of a person or thing, so called because such discourses used to be delivered in ancient Greece on the occasion of great public festivals before the whole assembly, "panégyris," of the people. Afterwards the name came to be applied to political orations delivered in the senate or council of a state in praise of that state or of the leading men or man in it. The panegyrical oration of Isocrates is a fine specimen of the kind, in which he commemorates the glories of Athens, the services which it had rendered to Greece in general, and the whole with a view to nourish friendly feelings between it and the other Greek states.

Under the Roman empire panegyrics were composed in praise of the emperors, Pliny's panegyric of Trajan is a well known specimen of this kind. Panegyrics became frequent under the late emperors, both of the East and the West, in Greek and in Latin; they are mostly however written in a fulsome and adulatory style. We have panegyrics of Constantine, Constantius, Justinian, Theodosius, and others, which, if consulted with discrimination, may be useful for historical purposes and for supplying deficiencies in the historians of those times. Eunodius, bishop of Pavia, wrote a panegyric in praise of Theodoric.

Panegyrics have also been written in verse. The poem of Tibullus in praise of Messala is a specimen of this kind, as well as similar compositions by Claudianus, Sidonius, and others.

In modern times panegyrics have been written by Roman Catholic preachers in honour of particular saints. Giordani, an Italian contemporary author, wrote a panegyric in praise of Napoleon, in imitation of that of Pliny. But the panegyrical style seems no longer in accordance with the taste of our age, and its essential character is too laudatory to please minds of an independent cast. The *éloges* on deceased members of the Académie Française are perhaps the only existing examples of the old panegyric.

PANEL. This term in English law denotes a small schedule of paper or parchment containing the names of the jurors returned by the sheriff for the trial of issues in courts of common law. The enrolment of the names upon this schedule is the *array*. The etymology of the term is doubtful; Sir Edward Coke says, "Panel is an English word, and signifieth a little part, for a *pane* is a part, and a panel is a little part' (Co. Litt., 158 b). Spelman derives the word from *pagella*, a little page, supposing the *g* to be changed to *n*. (Spelman's 'Gloss.,' tit. "Panella"). Both these etymologies seem to be incorrect. In the old book called 'Les Termes de la Ley,' *panel* is said to come from the French word *panne*, a skin; whence in barbarous Latin might come *panellus* or *panella*, signifying a little skin of parchment. This would denote the jury panel pretty accurately, and the history of its appearance as an expression in English procedure is consistent with its derivation from the French.

In the earliest records of the forms of jury-process, as given by Glanville, it appears that the sheriff was commanded by the writs in certain real actions to cause to be imbreviated (imbreviari facere) the names of the jurors by whom the land in question was viewed. But at this time the word *panel* never occurs, nor is it used by Bracton, Fleta, or Britton, nor in any statute earlier than 20 Edw. III., c. 6 (1349), which forbids sheriffs from putting suspected persons in *arrays of panels*. This was precisely the period at which the French language began to be fully introduced into our law proceedings. (Luder's 'Tract on the Use of the French Languge in our Ancient Laws.')

In Scotch criminal law, the accused, who is called a defender till his appearance to answer a charge, is afterwards styled the *pannel*. The etymology of this word also is doubtful. (Jameson's 'Dictionary,' ad verb.) But it is possible that it may have the same origin as our English word, as in Scotch proceedings a prisoner is sometimes said to be *entered in pannel* to stand trial. (Arnot's 'Criminal Trials,' p. 12.)

PANOPTICON. [BENTHAM, in BIOG. DIV.]

PANORA'MA (from the Greek word πᾶν, all, and ὅραμα, a view), a picture showing a view completely around the spectator. This ingenious pictorial contrivance was first devised by an English artist, Robert Barker, about the year 1794: and is not so much a new mode of painting—the process itself being similar to scene-painting or *in distemper*—as a novel application of it. Contrary to the diorama [DIORAMA], the panorama forms the surface of a hollow cylinder, or rotunda (whence it is frequently called in German *Rundgemälde* or *Rundbild*,—cyclorama), in the centre of which is a detached circular platform for the spectators, covered overhead to conceal the skylight, and thereby increase the illusion and give greater effect to the painting itself. The latter is not painted on the walls, but upon canvas, like the scenes of a theatre, and afterwards fixed up, in order that the views may be changed, and a fresh one may be in progress while another is open for exhibition. Yet although there is nothing whatever particular in regard to the execution or process of such pictures, they are attended with difficulties which can be mastered only by practice and experience. The first of these arises from the circumstance that the artist cannot either concentrate his light or adapt the direction of it arbitrarily as best suits his purpose, but while portions of his view will be entirely in sunshine, the opposite one will be almost a mass of shadow; the second is the difficulty of representing on a curved surface the straight horizontal lines of buildings; the third and greatest of all is, that there can be no single fixed point of sight, since the eye traverses around the whole circle of the horizon. Hence it might be supposed that many parts of such a picture would appear, if not quite distorted, more or less out of perspective. Yet such is not the case, no doubt partly because the eye accommodates itself to certain principal points fixed upon by the artist as centres of vision, and on account of the optical fascination attending the whole. The subjects generally chosen are views of cities, or interesting sites, whose entire locality and buildings may thus be vividly placed before the eye in a manner no less instructive than it is interesting.

Among the largest panoramas hitherto attempted was the view of London by day, and of Paris by night, at the Colosseum in the Regent's Park. An improvement on this sort of panorama, is what is styled the moving panorama. This, which is also painted on canvas, by being wound on and off a cylinder, has been used to depict a continuous extent of scenery of many thousands of miles. Such were the panoramas of the Mississippi and Ohio rivers, and many others.

PANSY, a corruption of the French *pensée*, is a name now chiefly applied to the garden varieties of Viola tricolor, Attaica, and others, which are commonly cultivated under the name of Heart's-ease. These plants, being all nearly allied to each other, have proved an abundant source of hybrids, which by repeated crossing and selecting, have at length been so much improved in their appearance that it is not uncommon to meet with single flowers as large as a penny piece, although the wild blossom of Viola tricolor will hardly cover a sixpence. When skilfully managed, they are great ornaments of the flower-beds in a garden, but they are short-lived, and require to be continually renewed by seeds or cuttings. They love damp rich soil, not too much exposed to the sun, and are thought to acquire the greatest health and beauty when planted in beds of light rich earth upon a thick substratum of cow-dung, into which their roots will quickly penetrate.

PANTHEON. [ROME, in GEOG. DIV.]

PANTOGRAPH, sometimes improperly called PENTAGRAPH, is an instrument employed in copying maps, plans, and other drawings.

The annexed diagram represents that most commonly in use.

It is composed of four brass rules or bars, jointed to each other at the points B D E F. These joints require to be carefully executed, as upon the smoothness and steadiness of their motion the accuracy of the instrument principally depends. In those of the best construction there is a small metal cock screwed to the bar of each joint, which supports the upper end of the axis upon which it turns. This is a material improvement upon the common flat compass joint, as, besides lengthening the axis, it gives additional strength to the bar where it most requires it. A joint of this construction is shown in *fig.* 2.

At the point C is fixed a small tube which carries the tracing point, so fitted as to move freely within it, but without shaking; *fig.* 3 represents the tracer within the tube. The bar E D and the lower part of the bar A B are furnished each with a tube, *fig.* 4, similar to that at C, but moveable on the bar, with a similar screw to fasten it down at any required point. *Fig.* 5 is the pencil stem, which fits either of the tubes in the same manner as the tracer; on the top of the stem is a cup to receive a small weight to keep it down upon the paper, and the lower end carries a pencil, or, which is better, a "Mordan's point." A silk cord is attached to the pencil stem, carried through eyes made for the purpose, over the joints E B F, one of which is shown on the top of *fig.* 2, and fixed in a notch in the top of the tracer, *fig.* 3, so that the pressure of the thumb upon the cord lifts the pencil from the paper when required. *Fig.* 6 is a flat leaden weight with a brass stem rising out of it, which fits in the tubes in the same manner as the pencil and tracing point; this is called the fulcrum, as being the point upon which the whole instrument moves; the weight has three or four fine points on its under surface to keep it from shifting upon the paper. The whole instrument is supported by six revolving feet or castors, which should move very freely in all directions. One of these castors is shown under the joint, *fig.* 2. The pin or fulcrum is placed near the edge of the weight, so as to allow room for the castor to work when the fulcrum is near the points A or D.

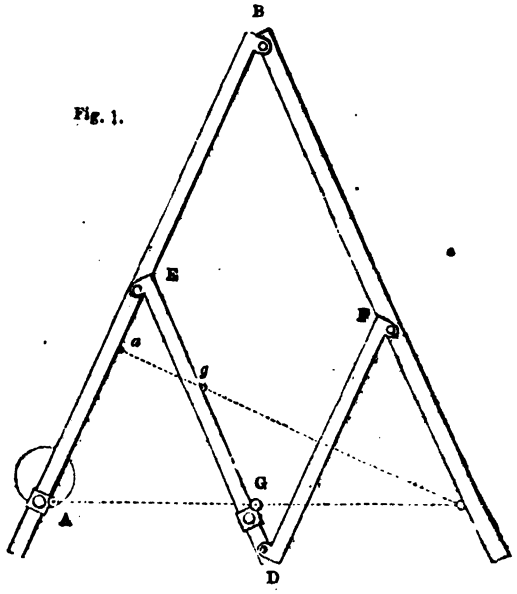


Fig. 1.

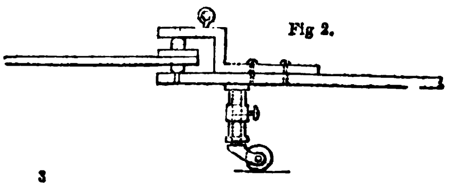


Fig 2.

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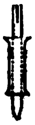

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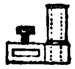

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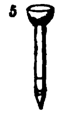

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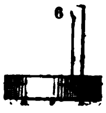


The proportion of the bars is of no consequence, so that E D is equal to B F and E B to F D, in which case they will always form a parallelogram, by which name the instrument is sometimes called. Now if the tracer at C is carried over the lines of the plan, the fulcrum-tube being fixed at A, and the pencil-tube at G, the pencil will make an exact copy of every line, but only half the size of the original, which may be proved in the following manner:—

The points A, G, and C, are capable of being brought close together, and when the instrument is open, as in the figure, G is exactly half way between C and A; C then travels twice as quickly as G in the direction A G C, so that to whatever extent the pantograph may be opened, G and C being considered as points in a lever of which A is the fulcrum, it will be seen that if C is made to describe an arc of a circle of any radius, G at the same time is describing an arc of a circle of half the radius, so that C moves in a direction perpendicular to A G C twice as fast as G. Now it was shown above that it moved twice as fast as G in the direction A G C, and as by the composition of these two motions, all lines, whether rectilinear or curved, are produced, it follows that the pencil at G will produce a copy half the size of the original traced over by the point at C, as before stated.

To produce a copy one-fourth the size of the original, we must shift the pencil from G to *g*, and the fulcrum from A to *a*, *a g* being one-fourth the length of *a* C, and so on for all other proportions *less* than half, the constant rule being—"As the distance of the pencil from the fulcrum is to the distance of the tracer from the fulcrum, so will be the size of the copy to that of the original." No calculation is required in practice, as the arms A E and E D are graduated for all proportions from one-twelfth to eleven-twelfths inclusive. If it be required to produce a copy *more* than half the size of the original, the fulcrum must be placed on the arm E D, and the pencil on A E, the rule above given still holding good, so that for a copy the *same size* as the original the fulcrum must be placed at G, and the pencil at A. It must be borne in mind, however, that when the fulcrum is on the arm E D, the copy will be inverted.

Though the principle of this instrument is as simple and complete as can be imagined, yet it falls sadly short of perfection in practice.

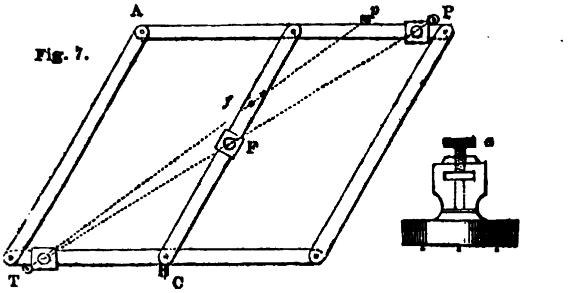
In the first place the numerous joints and castors, however carefully constructed, make it heavy to the hand in comparison with the unfettered pencil, and it requires much practice to be able to manage it so dexterously as to get those minute and gentle undulations, necessary not only to the beauty but to the utility of the drawing. The pencil too, constantly working upright, does not maintain that fine point which is required for distinctness of outline, and to these faults we must add inaccuracy of workmanship, however slight, the effect of wear, inequalities of the paper, and other accidents.

The best way to test an instrument is to reverse the position of the tracer and pencil, thus producing a copy larger than the original, when the defects will of course be exaggerated in proportion.

The pantograph, however, though it cannot be depended upon for an accurate and finished copy, is of great service to the draughtsman, for by it may be marked off all the principal points through which to draw the lines of a plan with equal accuracy and infinitely greater facility than by any other means used for the purpose.

The annexed engraving represents a pantograph which possesses some advantages over that before described. In the first place, the fulcrum being in the centre, it requires but one castor, which is placed at C, and makes it work much lighter in hand than the old instrument, which has six; besides which these six castors are frequently a source of annoyance by getting off the edge of the drawing-board and running over drawing-pins or anything else which may happen to be in the way. Secondly, the shape of this instrument allows it to move as freely when nearly closed as when opened wide, which is not the case with the other. This improved instrument consists of six bars, moving freely about each other at the six points of juncture, so arranged with regard to length that A P and T B are always parallel to each other. F is the fulcrum, furnished with a socket and screw (*a*), through which the centre bar can be moved, and which can be fastened down at any of the graduations on that bar. This socket, with the bar, turns upon the pin rising out of the centre of the flat weight, as shown in the diagram. Now the tracer T, the fulcrum F, and the pencil P must always be in a straight line. To produce a copy the same size as the original, the fulcrum must be in the centre, and the pencil and tracer, as in the engraving, equi-distant from the centres of their respective arms, and consequently from the fulcrum. For a half-sized copy the pencil must be shifted half way up the arm to *p*, and the fulcrum to *f*, in the straight line T *f p*, and so on for any required proportion, which is apparent by a glance at the diagram. The rule laid down in regard to the other instrument holds good for this, the copy bearing the same proportion to the original as the distance of the pencil from the fulcrum does to that of the tracer.

Fig. 7.



In using the pantograph it is frequently necessary to copy the drawing in divisions, on account of the instrument not being large enough to extend over the whole surface at once. In this case the greatest care is requisite to join the lines of one division accurately to those of the adjoining division. The best way of effecting this is to hold the tracer down upon a point in the original by one hand, moving the fulcrum about with the other, until the pencil exactly coincides with the corresponding point in the copy. To ensure accuracy, this should be tried with three or more points, as the least deviation will throw the whole plan out of position.

In practice a large number of plans are copied of the same size as the original. The quickest method, which, however, requires great care, is to pin down a piece of tracing-paper upon the original, on which the lines are marked with a fine-pointed pencil. A piece of paper rubbed over with blacklead is then placed upon the paper intended for the copy, with the black side downwards, and the tracing-paper is pinned down upon it; the lines then are carefully traced over with a steel point, and the pressure transfers the blacklead to the drawing-paper beneath. The black paper is sometimes omitted, and the lines, traced by slight indentations only, are finished by hand, in the usual manner.

If it is required to reduce a plan, and the draughtsman does not possess a pantograph, the usual way is to divide the original and the paper for the copy, whatever the relative size, into the same number of squares, which will of course then bear the same proportion to each other as the surfaces of which they are divisions. The lines must then be set in singly, either by the assistance of the proportional compass or scale, or by a geometrical scale drawn for the occasion. The following method is dependent only upon the compass and T square.

Draw a triangle in which A B is the base, and make A C bear the same proportion to C B as you wish the copy to bear to the original; take any distance on the original, and set it off from B on B C, draw a line parallel to A B, and that portion of A C cut off by such parallel will bear the required proportion to the distance set off on B C, as may be seen by the divisions 1 2 3 4 on the two sides of the triangle in the diagram. The triangle should be drawn in ink, and the distances, being marked in pencil, may be rubbed out when transferred to the paper. [EIDOGRAPH; PROPORTIONAL COMPASSES.]

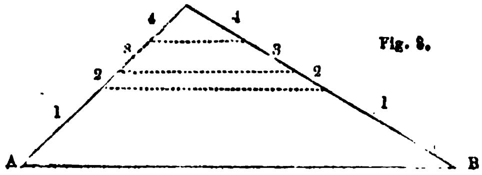


Fig. 8.

PANTOMIME, the name of a species of dramatic performance in which the actors express themselves by gestures. The name is composed of two Greek words, meaning "imitation of every thing." Pantomimic acting, accompanied by music, has been in use among the Chinese, Persians, and other Oriental people from the oldest times. The Greeks introduced the pantomime in their choruses, some of the actors dancing and gesticulating, accompanied by music, whilst others sang. (Lucian, 'De Saltatione.') The Romans had entire dramatic representations consisting of dance and gestures only, styled "saltatio pantomimorum," and some of their performers attained a high degree of excellence in the art. Two of them, Bathyllus and Pylades, in the time of Augustus, have been celebrated by the Roman writers.

In modern times pantomimic balls, representing an entire dramatic action or fable, have become a favourite scenic performance. The Tuscan Angiolini, in the last century, and after him Viganò, who died at Milan in 1821, have excelled in this species of composition. Noverre, in France, distinguished himself likewise in the composition of pantomimic "ballets." The name is now commonly applied to the harlequinade theatrical performances exhibited in London at Christmas and Easter.

(Meursius, *Orchestra;* Signorelli, *Storia Critica dei Teatri antichi e moderni.*)

PAPAVER. OPIUM, *Medical Properties of.* The juice of the unripe capsule or fruit of the *Papaver somniferum* seems to have been used on account of its narcotic powers from a very early period, first in the East, of which it is a native, and afterwards in the West.

As to the two varieties of the *P. somniferum,* called *P. S. album,* in which the seeds are white, and the openings under the stigmata obliterated, and *P. S. nigrum,* in which the seeds are blackish-gray, and the openings under the stigmata perfect, some differences are found in the relative proportion of some of the chemical constituents of the opium procured from them; but the *P. S. album* (*Papaver officinale,* Gmelin) is the kind chiefly cultivated in Persia and India.

"The first sophistication which the juice receives is that practised by the peasants who collect it, and who lightly scrape the epidermis from the shell to augment the weight. This operation adds about one-twelfth of foreign matters. Thus collected, opium has the form of a glutinous and granular jelly. It is deposited in small earthen vessels, and beat up with saliva. On inquiring why water was not employed in the place of saliva, the answer was, that water caused it to spoil. It is afterwards enveloped in dry leaves, and in this state is sold. The seeds of those poppies which have yielded opium are equally good for sowing the following year." Such is the account by M. Ch. Texier, of the plan in Asia Minor. A change of seed, however, by obtaining some from a distant locality, seems expedient. (Dr. Eatwell, in 'Pharm. Journal,' vols. xi. and xii., 1852.) In India, the juice is mixed with oil obtained from the seed of the poppy, to hinder the rapid drying of the juice. The produce of the first excisions is of a light yellow colour; the others are fainter in odour and darker coloured. In general, all three gatherings are mixed together, and sent to market in small baskets. The quantity obtained varies not only with the soil and mode of cultivation, but also with the season and the time of collecting. In wet gloomy seasons, not only is the quantity less, but it does not keep well; in such a case the proportion of *morphia* is also less. The quantity of morphia depends likewise very much on the time of gathering: if the harvest be postponed till the capsules begin to turn white and hard, it is generally deficient, and by the time the capsules are mature and the seeds ripe it has entirely disappeared. It is not, as is the case of many other vegetable alkaloids, transferred to the seeds, as they are altogether devoid of any narcotic principle, the oil which is obtained from them being bland and wholesome, and abundantly used as food; even the seeds themselves are freely eaten by birds, to which they are given (from the black variety) under the name of maw-seeds. In India and Turkey they are made into comfits, or strewed over sweetmeats, like carraway seeds.

Several varieties of opium are met with in commerce, which may be noticed here in the order of their reputed excellence, the quantity of morphia contained in each being assumed as the criterion.

1, *Smyrna* or *Levant opium,* which Dr. Pereira considers synonymous with Turkey opium, though German pharmacologists deem Turkey and Egyptian opium to be synonymous. (Th. Martius, 'Pharmakognosie.') "It occurs in irregular roundish or flattened masses of various sizes, rarely exceeding two pounds in weight, enveloped in leaves, and surrounded with the reddish triangular capsules of several species of *Rumex*, such as *R. orientalis, R. patientia* (which are employed to prevent the masses cohering to each other while the opium is soft). When first imported, the masses are soft, and of a reddish-brown colour; but by keeping they become hard and blackish, and on this account it is termed by the French *opium noir*. Its consistence is soft, at least of the interior, even when the exterior is very hard. Its lustre is waxy; the taste, bitter, acrid, and persistent.

2. "*Constantinople opium*. Of this there are two sorts: one in large irregular cakes, which are flattened, like the Smyrna opium, and of very good quality; the other is in small flattened regular cakes, of a lenticular form, from 2 to 2½ inches in diameter, and covered with a poppy-leaf, the midrib of which divides the disk into two parts. It has an odour similar to the preceding kind, but more feeble; at first it is reddish both without and within, hence called by the French *opium rouge*; it however blackens and dries in the air, but never becomes so hard as Smyrna or Egyptian opium, than which it is more mucilaginous." Th. Martius is of opinion that it is a manufactured article, prepared at Constantinople, out of Smyrna opium, by the addition of gum. It is a common article of German, but rarely of English, commerce. It is never covered with the *Rumex* capsules as the Smyrna opium.

3. *Egyptian* or *Alexandrian opium* "occurs in round flattened cakes of about three inches in diameter, covered externally with the vestiges of the same leaf, which are in too mutilated a state to be determined. It is distinguished from the preceding varieties by its reddish colour, analogous to soccotrine or hepatic aloes, which does not by time or exposure to the air become darker; the odour is fainter and somewhat musty." Though the cakes are all of the sorts much the hardest, so that a blow with a hammer will cause one to split into fragments, yet by exposure to the air it becomes soft.

4. "*Trebizond* or *Persian opium* occurs in the form of cylindrical sticks, which by pressure have become somewhat angular. Their length is about six inches; their diameter about six inches. Each one is enveloped in a smooth shiney paper, and tied with cotton. The colour of opium is similar to that of soccotrine aloes. It possesses a stronger odour than the Egyptian kind, but fainter than that of Smyrna, united with a musty one. The taste is intensely bitter."

5. *Indian opium*, of which there are several varieties, as already described. [Opium Trade.]

6. *English opium* "is in flat cakes or balls enveloped in leaves. It resembles the Egyptian more than any other kind; its colour is that of hepatic aloes, with a moderately strong opiate odour."

Before offering a summary of the points of difference, in chemical composition and other respects, of these various sorts, it is necessary to enumerate the general constituents of opium:—1, morphia; 2, codeia; 3, paramorphia or thebaine; 4, pseudomorphia; 5, narcotina or opianum; 6, narceine; 7, meconine; 8, meconic acid; 9, an oily acid; 10, gum; 11, resin; 12, extractive; 13, a fixed oil; 14, caoutchouc; 15, a volatile odorous principle; 16, ligneous matter with inorganic salts, such as sulphate of lime and potass, and in some kinds opiania, papaverine, and porphyroxine, the latter principle only in Bengal and Smyrna opium (according to Merck, its discoverer, 'Pharm. Central Blatt,' June, 1837). There are also various accidental but more intentional impurities, such as sand, of which even the best Smyrna opium contains a large portion, 10 ounces of opium frequently containing 10 drachms of stones and gravel. In the interior of the cakes leaden bullets are often discovered. The cakes should always be cut through the centre in order to detect this fraud.

The relative proportion of these numerous ingredients varies very much, not only in the samples from different countries, but in those of the same country. Thus, Smyrna opium, though the average quantity of morphia which it yields may be stated to be 10 per cent., in five specimens examined by Mulder gave 10 per cent. in the best and little more than 2 in the worst.

Professor Guibourt states Constantinople opium to yield only one-half the quantity of morphia procurable from Smyrna opium; while Mr. Duncan of Edinburgh has obtained even 14 per cent. Guibourt also affirms that Egyptian opium yields only 5-7ths of the morphia obtainable from Smyrna opium; while Dr. Christison procured 10½ per cent. from it. Of the Indian kinds, Dr. Smyttan procured only 3 or 5 per cent. of morphia, while Dr. Christison obtained 9½ from the Malwa opium; and from Bengal opium Dr. Smyttan obtained 2 or 3½ per cent., while Mr. Macfarlane of Edinburgh procured 7 per cent.

From English opium 5 per cent. may be obtained. From German opium Blitz procured 16½ to 20 per cent. From some French opium Petit obtained 16 to 18 per cent, and Caventou the large amount of 22 to 28 per cent.

The extreme discrepancy of these results may be explained not merely by the varying seasons when the specimens were produced, and the different degrees of skill and dexterity in the chemists, but by the fact that the morphia is more easily and effectually separated when the opium is fresh: hence the large proportion found in European opium, which was not only cultivated with great care, but was analysed soon after it had been collected. It is not at all improbable that the morphia undergoes a change by age, and entirely evaporates from old specimens, in the same way as conia disappears from hemlock. [Conium, in Nat. Hist. Div.]

It is always proper to institute an examination into each new purchase of opium, to ascertain the presence and amount of morphia. Some specimens of opium, which to the eye present all the physical characters of the best Smyrna opium, even some of those deemed hitherto inimitable, such as the transparent agglutinated tears seen on cutting it across, are found on analysis devoid of the smallest trace of morphia. ('Journal de Pharmacie,' tom. xxiv., pp. 325, 446.)

The following test is proposed in the 'New Edinburgh Pharmacopœia,' and though not absolutely certain, is sufficiently so for common use:—"A solution from 100 grains, macerated 24 hours in two fluid ounces of water, filtered and strongly squeezed in a cloth, if precipitated by a cold solution of half an ounce of carbonate of soda in two waters, and heated till the precipitate shrinks and fuses, will yield a solid mass on cooling, which weighs, when dry, at least 11 grains; and if pulverised, dissolves entirely in solution of oxalic acid."

More morphia would appear to be present in the specimens of European opium, which are obtained from the variety of poppy with violet-coloured petals, than in the Turkey opium; while that from the European white variety contains more narcotine than the Turkey. In Smyrna opium the morphia seems to be united with meconic acid, and to be not only more abundant, but more easily separated, and more completely purified from the narcotine and colouring matter, than that of Egypt, in which the morphia is united to sulphuric acid.

The following table, by Dr. Pereira, will show at one view the principal characters of the crystalline constituents of opium:—

Tabular View of the Principal Characters of the Crystalline Principles of Opium.

Characters.	Morphia.	Codeia.	Narcotina.	Meconine.	Narceine.	Paramorphia, or Thebaine.	Pseudomorphia.
Taste	Bitter	Bitter	Insipid	Rather acrid	Slightly bitter and metallic	Rather acrid and metallic	..
Fuses at	Above 240°	320°, or in boiling water	338°	194°, or in boiling water	198°, or in boiling water	302°	Hardly fusible
In cold water	Nearly insoluble	Soluble in 80 parts	Insoluble	Soluble in 265 parts	Soluble in 375 parts	Scarcely soluble	Almost insoluble
In boiling water	Soluble in 100 parts	In 17 parts	Slightly soluble	In 18 parts	In 230 parts	..	Almost insoluble
In cold alcohol	Soluble in 40 parts	Soluble	In 100 parts	Soluble	Soluble	Soluble in 10 parts	Almost insoluble
In cold ether	Sparingly soluble	Easily soluble	Easily soluble	Soluble	Insoluble	Very soluble	Almost insoluble
In caustic alkalies	Soluble	Insoluble	Insoluble	Soluble	Insoluble	Insoluble, except in very concentrated solutions	Very soluble in potass and soda
Chlorine	..	..	..	Coloured blood-red	..	..	..
Iodine	..	..	..	..	Coloured blue	..	..
Nitric acid	Coloured red	..	..	Yellow	If dilute, blue	Yellow	Coloured red
Hydrochloric acid	..	..	..	..	Blue	..	..
Iodic acid	Iodine set free	..	..	..	..	..	..
Perchloride of iron	Coloured blue	..	..	..	..	..	Coloured blue
Infusion of galls	Precipitate	Precipitate	Precipitate	..	..	..	..
Nitrogen	Present	Present	Present	..	Present	Present	Present
Water of crystallisation	2 atoms	2 atoms	..	Absent ..	..	2 atoms	..
Atomic weight	292	284	446	97	298	202	306
Action on vegetable colours	Alkaline	Alkaline	No effect	No effect	No effect	Alkaline	..
Relation to acids	Salifiable	Salifiable	Salifiable	Not salifiable	Not salifiable	Not salifiable	Not salifiable
Effects	Poisonous; a cerebro-spinant	A cerebro-spinant	Inert ?	Inert ?	Inert ?	Causes convulsions	Not poisonous

The great pains now taken in the culture and preparation of Indian opium induce a preference for it over the other kinds. If Indian opium contain generally more narcotine, it is on that account perhaps better suited to cases in which the stimulating action is wished.

Good opium is not perfectly soluble in water; $\frac{1}{12}$th generally remains undissolved, consisting of the caoutchouc and resin. Constantinople opium, however, leaves no residuum of caoutchouc. When opium is entirely soluble in water, it may be suspected to have been prepared by boiling the bruised capsules and leaves, and it is of a very inferior kind. The specific gravity of good opium is 1·336, if great mechanical impurities are not present. It is very inflammable, and burns with a clear flame, and forms a transparent alcoholic solution. Opium from the bruised capsules is not inflammable, and forms a turbid alcoholic solution. When gum arabic or tragacanth is used to adulterate it, the specimen forms, when rubbed with one part of alcohol and two of water, a tremulous gelatinous mixture.

It must be obvious that a substance of so complicated a nature cannot act uniformly on organised beings, even supposing them to be always constituted alike, which never is the case, since they vary according to age, constitution, habits of life, states of disease and idiosyncrasy, &c. Some of the effects which follow the employment of opium have been attributed to one prinicple and some to another; but, with a few exceptions, nothing positive has been ascertained. Morphia is by no means the only sedative principle; and narcotine, so long regarded as the stimulating principle, is, when pure, nearly if not quite inert. The odorous principle is unquestionably powerful, though it has no resemblance to hydrocyanic acid. The collectors of opium are generally pale and affected with tremblings. If opium be heated, the odour evolved is fatal to animals, and persons have fallen down in a state of insensibility from breathing an air charged with the vapour of opium in some pharmaceutical processes.

It is most probable that the extractive and resinous principles, with the meconic acid, which seems to modify the properties of the morphia, are the stimulating ingredients of opium, and that the getting rid of some or all of these, as in the watery extract of opium, and a few of the secret preparations of opium, constitute the superiority of these preparations, as calmants, over crude opium, or the officinal preparations in which they are retained.

A most extensive series of experiments have been instituted to determine the effects of opium: on vegetables by Marcet and Macaire; on animals by Charvet; and on man by numerous physiologists, including Charvet. From these it appears that opium acts as a poison to plants, by destroying their irritability. According to Charvet, in the case of the sensitive plant, where the opium failed to kill the subject of experiment, and it slowly recovered its irritability, yet the further growth was completely stopped. "In the animal kingdom, Charvet tried its effects on mammals, birds, reptiles, amphibia, fishes, insects (both in their perfect and larval states), the annelides, the mollusca, polypiphera, and polygastrica, and found that it acted on all as a poison, but with somewhat different effects according to their organisation. Thus on man it may produce congestion of the brain (marked by sopor and apoplectic symptoms), or irritation of the brain and spinal marrow (indicated by convulsions and pain), or a sedative effect (manifested by paralysis).

In other mammals, two kinds of effects are seen for the most part; the one of irritation, the other of diminished nervous power, symptoms of congestion being altogether wanting or very slight. This difference of effect corresponds with a difference in the development of the brain.

In the invertebrated animals, no symptoms of irritation seem to be caused by opium. This poison in them acts only on the contractile tissues, and produces symptoms of weakness or loss of contractile power.

In the animal series, the action of opium varies with the degree of development of the nervous system; and in the lowest orders the effects are quite analogous to those observed in vegetables. (Pereira.) (See Wilmer, 'Die Wirkung der Arzneimittel und Gifte in gesunden therischen Körper,' in which all the experiments are given in a classified arrangement.)

Much disputation has taken place respecting the question, whether opium be a stimulant or a sedative, and most unnecessarily, as its action depends, in general, on the quantity taken, the frequency of repetition, and the state of the system when it is administered. That to persons in health, if the dose be small, it is a stimulant, seems unquestionable; and this is proved by the fact that the habitual opium-eaters consume it for the sake of its primarily stimulant effect, and not for the sake of the depression, languor, and suffering which succeed. The different degrees of action, resulting from a difference of dose, are so ably given by Dr. Pereira that they may be quoted here verbatim.

1. *First Degree of Operation.*—"In small doses, such as from a quarter of a grain to one grain, opium generally acts as a stimulant, though in this respect the symptoms are not uniform. Usually the vascular system is somewhat excited, and a sensation of fulness is experienced about the heart. The excitement in the cerebral vascular system is accompanied by alterations in the condition of the nervous functions. The mind is exhilarated, the ideas flow more quickly, a pleasurable or comfortable condition of the whole system is experienced, which is difficult to describe; there is a capability of greater exertion than usual. These symptoms are followed by a diminution of muscular power, and of susceptibility to the impression of external objects; a desire of repose is experienced, with a tendency to sleep. While these effects are taking place, the mouth and throat become dry, and hunger is diminished, though the thirst is increased; and slight constipation usually follows.

"Such are the common effects of a small dose of opium on persons unaccustomed to its use; but by repetition the influence of this agent becomes remarkably diminished, and those therefore who resort to it for the purpose of producing a pleasurable stimulus are obliged to increase the quantity in order to keep up an equal effect.

2. *Second Degree of Operation.*—"Given in a full medicinal dose, such as two or four grains, the stage of excitement is soon followed by that of depression. The pulse, which at first is increased in fulness and frequency, is afterwards reduced below the natural standard. The skin becomes hot, the mouth and throat dry, the appetite diminished, the thirst increased, and frequently nausea or even vomiting is induced. The symptoms of excitement soon pass away, and a state of torpor succeeds; the individual feels indisposed to exertion, the muscular system appears enfeebled, the force of impressions on the organs of the senses is diminished, and the ideas become confused. This state is followed by an almost irresistible desire to sleep, which is frequently attended by dreams, sometimes of a pleasing, at others of a frightful nature.

"These effects are usually succeeded by constipation (which may continue for several days), by nausea, furred tongue, headache, and listlessness."

3. *Third Degree of Operation; Poisonous Effects of Opium*, as given by Dr. Christison.—"The symptoms of poisoning with opium, when it is administered at once in a dangerous dose, begin with giddiness and stupor, generally without any previous stimulus. The stupor rapidly increasing, the person becomes motionless and insensible to external impression; he breathes very slowly, generally lies quite still, with the eyes shut and the pupils contracted; and the whole expression of the countenance is that of deep and perfect repose. As the poisoning advances, the features become ghastly, the pulse feeble and imperceptible, the muscles exceedingly relaxed, and, unless assistance is speedily procured, death ensues. If a person recovers, the stupor is succeeded by prolonged sleep, which commonly ends in twenty-four or thirty-six hours, and is followed by nausea, vomiting, giddiness, and loathing of food."

The quantity which can produce a fatal effect in a person unaccustomed to its use is very small, even four grains; and in children, owing to the large quantity of blood which naturally goes to the brain, and the great impressibility of their nervous system, a very minute portion of opium, or of its numerous preparations, open or disguised, can produce death. These facts constitute a strong reason for unskilful persons refraining from its employment, and also for avoiding in this place all details connected with its medical use. It is undoubtedly one of the most important means of alleviating human suffering when appropriately administered, and yet one of the greatest banes when abused. It is by the self-doctoring in general that the practice of opium-eating is acquired; and it is the more necessary to warn such persons against commencing the use of it, even for the legitimate purpose of overcoming disease, as they may inadvertently lapse into habits which they may never be able to shake off. Further, it should be known by those who are disposed to adopt this practice, that the habitual consumers of this drug have recourse to it again and again, not so much for the sake of the pleasurable sensations it can excite, as to *escape the misery*, mental and bodily, which their previous indulgence has entailed upon them. (Dr. Oppenheim's State of Medicine.')

It is necessary to place this statement before the public, as there is reason to believe that the practice of taking opium is becoming common in this country, where other stimulants are relinquished. Besides the injury done to the moral faculties and the general health, the quantity required to procure the desired excitement becomes at last so great as to render it a most expensive, and, to the poor, a ruinous habit. It has been alleged, in cases connected with life-insurance, that this habit has no tendency to shorten life. But the instances adduced in support of this view are quite inadequate to warrant such a conclusion, and all those demonstrating the longevity of opium-smokers in the East are altogether inapplicable. The effects of opium-smoking are by no means so pernicious as those of opium-eating. The preparation which the opium undergoes seems to disarm it of much of its injurious property. The Chinese employ only the soluble part of the opium after it has been half roasted, which they term smokeable extract, or *chandoo*, of which 50 or 51 per cent. is obtainable from Patna opium, and 70 to 75 per cent. from Malwa opium. This extract retains all the bitterness of the opium, but has not in the least degree the virose and nauseous odour which characterises crude opium. The more it has a brown colour, the milder and more agreeable is the odour. If well prepared, it resembles the taste of hazel-nuts. It is not mixed with tobacco, as some writers assert, and is smoked out of a very different kind of pipe,—one made of a cane of bamboo with two joints to it. The smoke is held in the mouth as long as possible, and then expelled through the nostrils. It is rarely swallowed, and if it should reach the stomach it generally causes some temporary disturbance of that organ. The Chinese use it both before and after meals, but if taken too soon after food it causes sickness. It seems to excite the bodily powers, but creates little derangement of the intellectual faculties, and does not occasion dreams, as opium-eating does. It appears to be an almost necessary stimulus in a climate where languor and listlessness so commonly prevail. Enjoyed in moderation it has no bad consequences. These statements are confirmed by the accounts of Dr. Burnes ('Narrative of a Visit to the Court of Sinde,' p. 230), and above all, by that of Botta (Froriep's-'Notizen,' xxvi.), who made trial during a period of twelve months on himself, and found his general health in nowise affected. Strict philosophical inquiry must not be influenced by casual circumstances, and least of all should it be biassed by the rash assertions of those who debate the question of the effects of opium with the violence of partisans or the partiality of interested dealers. (See 'Quarterly Review,' vol. lxv., March, 1840, 'On Chinese Affairs,' written by Sir John Barrow.)

Of the treatment of a case of poisoning with opium, little need be added to what has been said under ANTIDOTES, and NARCOTICS. The first object is to empty the stomach, and as emetics can scarcely be made to act, the stomach-pump should be assiduously used. The next object is to obviate the disposition to sleep. This may be done by keeping the person walking about as much as possible, and also applying cold and hot water alternately, as recommended by Dr. Boisragon ('Medical Gazette,' March 7, 1840), perseverance in which will often rescue the patient from imminent danger. When all the opium is removed from the stomach, vinegar, or coffee boiled in vinegar, may be drank at short intervals. Moderate venesection (if the pulse be full) is sometimes of service, and carrying on artificial respiration is a most beneficial measure. The subsequent constipation requires attention.

A modification of Dr. Marshall Hall's plan of treating drowned persons, when no longer able to stand or walk about, would be useful. One point in this plan is to avoid laying the patient on his back, but, on the contrary, on his face, with his arms folded under his head, and moving him from side to side so as to cause successive expirations and inspirations, sixteen times in the minute only. (See 'The Lancet,' April 12, 1856.)

The officinal preparations of opium are numerous, and are fitted for different purposes. It is to be regretted that they are not of uniform strength, as this proves a source of inconvenience, as well as sometimes of danger. The great variation in strength of the tincture of opium, as found in the shops, has been pointed out by Dr. Christison ('Edin. Medical and Surgical Journal,' vol. xlix., p. 329), and even a greater difference is to be found in the syrup of poppies, which as generally prepared is a feeble preparation, but in other instances so powerful as to prove, in the dose of a few drops, fatal to children. (See 'Returns from the Coroners of England and Wales, of all Inquisitions held by them during the years 1837 and 1838, in cases where Death was found, by Verdict of Jury, to have been caused by Poison,' laid before parliament, on the motion of Sir Robert Inglis.) Numerous also are the instances of deaths from mothers and nurses administering nostrums, such as Godfrey's cordial and other soothing medicines, the most potent ingredient in which is opium. Paregoric elixir, though a weaker preparation than tincture of opium alone, or laudanum, differs much in strength in the two kingdoms. Scotch paregoric elixir is only one-fifth of the strength of laudanum, while English paregoric elixir is four times weaker. Some secret preparations in extensive use are, on the other hand, considerably stronger, such as the black drop, Battley's sedative liquor, and Jeremie's sedative solution, which last is now much employed in India, and even in Britain. It seems not to be followed by headache or constipation, effects so inconvenient that to avoid them the alkaloids of opium have been substituted for the crude drug. Thus acetate and hydrochlorate of morphia often agree with the system, where opium is unsuitable; and a syrup of codeia is efficacious against the gastric disorders of tropical climates, where opium or morphia even cannot be borne. ('Journal de Pharmacie,' tom. xxiii. p. 418; et tom. xxiv., p. 144.)

The capsules of the white poppy are ordered to be used to form an extract, and a decoction which is employed as a fomentation. These should be collected before they become ripe, as all the morphia is dissipated afterwards. The petals of the wild field poppy, *P. rhoeas*, are used to form a syrup, which is only esteemed as a colouring material, and is not narcotic.

(Sachs, *Das Opium*, Königsberg, 1836; Charvet, *De l'Action comparée de l'Opium*; Christison, *On Poisons*; Pereira, in *Materia Medica*; and Holland, *Medical Notes and Reflections*.)

PAPAVERIC ACID. *Rheadic Acid.*—An acid of doubtful existence, said to be contained in the flowers of the wild poppy.

PAPAVERINE. [OPIUM, ALKALOIDS OF.]

PAPER HANGINGS, a term applied (somewhat incorrectly) to the stained, or rather coloured, paper pasted against the walls of apartments, &c. The word "hangings" was originally and properly applied to the woven or embroidered tapestry with which the walls of rooms in mansions were covered. From the time necessary for their production, these were too costly for any classes but the wealthy. About 200 years ago, however, a mode was devised of printing or painting a pattern on sheets of paper, and pasting them against the walls of a room; these are "paper-hangings," and they have greatly contributed to the comfort and cleanliness of domestic apartments. Before, however, actual *paper* hangings were adopted, there was a sort of intermediate plan by which textile material was employed. Jerome Lanyer, about the year 1638, produced what he called *tonture de laine*. This was cloth, on which a design was drawn in varnish or foot oil. A collection of *flock*, or powdered fragments of woollen, was at hand, different colours in different boxes; the flock was sprinkled on the cloth in a peculiar manner by the finger and thumb, and thus an attempt was made to imitate costly tapestries and brocades. When the cheaper material, paper, came to be employed, the device or pattern was printed in outline, with ink, on separate sheets of paper; the sheets were then joined edge to edge by paste, and the device was filled in by hand with distemper colour. The patterns were chiefly panels, containing groups of fruits, flowers, animals, small figures, grotesques, &c. About seventy years ago, there was a celebrated manufactory of paper-hangings at Chelsea, belonging to the Messrs. Echardts, where the best work was done. They employed many tasteful artists; they printed on silk and linen as well as paper; and the original blocks of some of their designs are still preserved.

As at present conducted, there are three modes of producing the required device. 1. Wooden blocks are carved, representing in relief the *outlines* of the figure; an impression is taken from these blocks, and the device is completed by painting with a pencil. 2. A sheet of paper, leather, tin, or copper, is cut out into the required device, and laid on the paper to be stained; a brush, dipped in a coloured pigment, and worked over the surface of the perforated plate, conveys the pigment through all the perforations, and forms a pattern on the paper. 3. A block is carved for each of the colours to be employed, and an impression from all the blocks in succession fills up the design on the paper. The first of these modes is too slow and costly for ordinary use; the second produces imperfect outlines, and is now chiefly employed (under the name of *stencilling*) to paint a pattern on the plaster walls of a room, without using paper-hangings; the third, which is the mode almost exclusively employed at the present day, we will now describe.

The paper is printed in pieces twelve yards long, and to produce these it was formerly necessary to paste sixteen or eighteen sheets of paper together at the edges. But machine-made paper now allows the paper-stainer to procure the whole length in one piece. A piece is laid out on a long bench, and the ground-colour applied, consisting of pounded whiting tinted by the addition of some pigment, and liquefied by the aid of melted size; this is laid on with large brushes. When the paper is dry, it is ready to receive the print. Let us suppose the pattern to contain three colours,—red, dark green, and light green, besides the ground or general tint. Three blocks are carved in hard wood, the uncut parts (as in a common wood-block) representing the device; each block is intended for one colour only; and care is taken that all three shall register or combine their devices properly, when printed. The blocks are of pear-tree, mounted on pine. The three pigments being mixed with melted size, in separate vessels, one of them (say red) is spread with a brush on a wooden frame covered with leather or flannel: the proper block is laid face downwards on the wet paint, takes up a layer of it, and imparts it to the paper, on which it is immediately pressed. Another similar impression is made adjoining the first; and so on, till the whole piece has been printed with the red device. When dried, the paper goes through the same process a second time, with the substitution of a different colour and a different block from those before used. A third process with the other shade of green finishes the printing. Each block is furnished with small pins at the corners, by the aid of which the successive impressions are made to correspond properly. Numerous colours are sometimes employed in one pattern, and generally speaking there must be as many blocks as there are colours.

Such is the hand-method, very largely adopted. This manufacture, however, has shared in many of the advantages which mechanical ingenuity has conferred upon letter-press printing, by the adoption of the *cylinder*. About the year 1840, Messrs. Potter, of Darwen, introduced machine-printing into the trade. By means of steam-power, artificial drying, and an endless roll of paper, they were enabled to produce patterns with good effect for paper-hangings, by surface-roller printing in different colours. Year by year has this art improved, until at length some of the patterns are produced by as many as fourteen cylinders, each printing one particular colour. This number of colours has even been increased to twenty, by a peculiar management of the cylinders. The machines can now print 20,000 yards in a day each, if simple in device and colours. The immense extension of the paper-hanging manufacture within the last few years, and the lowering of price, are mainly owing to this use of steam-power cylinder-printing. All the best work, however, is still done by hand (as in book-printing and calico-printing).

Besides the more usual varieties of paper-hangings, there are many special kinds. Some have a glossy or *satin* ground. To produce this, a ground of satin white, properly tinted, is laid on; this ground is then rubbed with powdered French chalk worked by means of a brush, until a gloss is produced. After this the printing proceeds as usual.

These satin papers sometimes receive an additional beauty, by being passed between two slightly heated rollers, one of which has an engraved pattern in imitation of watered and figured silk, &c.: this pattern is thus imparted to the paper. *Flock* papers are those in which a portion of the pattern somewhat resembles woollen cloth. We have already spoken of these, as originally produced; but in the present mode of manufacture, when the proper ground-colour has been applied, the device is printed, not with a coloured pigment, but with japan gold-size; and on this gold-size is sprinkled the flock, consisting of fragments of woollen cloth cut into a sort of down and dyed. The flock adheres to the gold size and can easily be brushed off the other parts. Sometimes flocks of two or three colours are employed; these are laid on at separate times. The French have acquired much skill in the preparation of these flock papers: some of their *embossed* and *shaded* flocks are very beautiful. *Striped* papers are sometimes produced in a singular manner. The colour (rather more liquid than in other cases) is contained in a trough having parallel slits in the bottom. The paper is made to pass quickly under the bottom of the trough, by means of a revolving cylinder, and thus obtains a deposit of colour in parallel lines, through the slits in the bottom of the trough. By a modification of this method is produced what is termed a *blended* ground. A trough, containing many distinct cells, is filled with various tints of any given colour, one tint to each cell. A long narrow brush being dipped into all these cells, takes up a portion of each tint, which it applies to a roller; from the roller the pigment is transferred to a revolving brush, and from the brush to the paper. Thus is produced a blended or shaded ground, which afterwards receives any desired pattern. *Bronze* or imitation gold-powder is frequently applied to papers. A device being printed in japan gold-size, the powder is lightly rubbed over the paper, and adheres to the gold-size. The remainder of the pattern is commonly printed in colours. In some wall-papers, leaf-gold, silver, or copper is applied to a portion of the pattern: this is a slow and expensive process. Other kinds, again, in order to bear washing or cleaning, are printed with colours mixed with oil or varnish instead of size. A modern kind called *oak* paper is produced in a remarkable way; the grain is printed from a piece of real oak, and is thus more true to nature than any block engraved by hand; by shaving off a few fibres, a new pattern of grain can be developed at pleasure. Among various novelties in the manufacture, one relates to the printing of the pattern in a direction *transverse* to the direction of the paper, and pasting the paper horizontally on the wall; the intention seems to be, to diversify the effect, by removing a sameness resulting from the usual plan.

A matter of a remarkable and somewhat important nature has lately come under public notice, in connection with the use of arsenic in the colouring of paper-hangings. Certain tints of green are produced, more permanent than other kinds available to paper-stainers; and these permanent greens contain arsenic. When a committee of the House of Lords was collecting evidence on the "Sale of Poisons" bill, in 1857, Dr. A. S. Taylor brought forward this subject. He stated that arsenic is more largely used for these greens than in any other English manufacture; and that workmen, as well as the occupants of houses, suffered thereby. Constriction of the throat, nausea, head ache, loss of appetite, &c. result. Instances had come under his notice, as a physician, tending to prove that rooms, hung with paper coloured with arsenic greens, are very prejudicial to health. Another physician, Dr. Hinds, detected a minute trace of arsenic in loaves of bread which had been placed on the shelves of a newly-papered shop, the paper being brilliant with arsenic-green. A working paper-hanger informed Dr. Taylor that he always suffered from inflamed eyes and nose, sickness, and giddiness, on the days when he was engaged upon green papers. The Prussian government, attending to the cautions of physicians and chemists, forbid the use of arsenic in any colours, whether distemper, or oil, for indoor work.

With regard to the *patterns* of paper-hangings, we may remark, that the attention which has lately been given to the promotion of the arts of design will probably lead to much improvement in the devices for paper-hangings, as well as for other ornamental productions. Mr. Owen Jones and other artists of distinguished ability, have supplied manufacturers with designs of a very superior character; but the great bulk of English designs are utterly inappropriate, and many, even when the paper-hangings are of an expensive kind, in extreme bad taste.

Sir Robert Peel made fiscal changes which greatly improved the paper-hanging manufacture. There used to be an import duty of 1*s.* per square yard on foreign paper-hangings; this was nearly prohibitory, and the home manufacturers had not the stimulus of foreign competition; when the duty, however, was reduced to 1¾*d.*, elegant French papers came in, and taught a lesson. A further improvement was made by lessening the duty on paper itself from 3*d.* to 1½*d.* per lb., and by wholly repealing the extra duty of 1¾*d.* per square yard on paper hangings. Whatever may be said as to taste in fine art, it is certain that cleanliness and comfort have been promoted by these reforms; seeing that wall-papers can now be sold at so very low a price as to come within the reach of nearly all classes. At present, nothing beyond the paper-duty of 1½*d.* per lb. (plus 5 per cent.) presses on the trade; yet it has been recently shown that this 1½*d.* is, in many cases, more than as much as the paper-stainer receives for all his expenses, labour, machinery, anxiety, risk, and profit of every kind. He buys a ream of self-coloured or ground-coloured paper, weighing 300 lb., and containing 480 pieces of 12 yards each; he gives for it 5*l.* 15*s.*, of which 1*l.* 19*s.* 4*d.* is for excise duty. He prints and sells it wholesale for 6*l.* 17*s.* 6*d.*, or 3½*d.* per piece; and this price is made up of 1¾*d.* for paper, 1*d.* for duty, and ¾*d.* for colours, tools, labour, machinery, rent, skill, risk, and profit.

PAPER MANUFACTURE AND TRADE. In early times the materials used for writing upon were chiefly such as only required some little mechanical fashioning to fit them for that purpose. Characters were engraved on flat stones made smooth, or were impressed in clay, which was afterwards dried and hardened by sun or fire, as in the case of the Babylonian bricks. Thin boards of wood covered with wax or some similar composition, and plates of ivory and of metal, have often been used. A more convenient material was afforded by the leaves of some species of trees. The skins and intestines of animals have also been made fit for writing upon; but wherever the Egyptian papyrus was introduced, all these things fell into disuse, except parchment, which is still preferred for certain purposes. [PARCHMENT; PAPYRUS.]

Paper Manufacture.—The art of making paper from fibrous matter reduced to a pulp in water appears to have been first discovered by the Chinese about the year 95 A.D. In the time of Confucius they wrote with a style, or bodkin, on the inner bark of the bamboo. The Chinese paper has been supposed to be made of silk; but this is a mistake. Silk by itself cannot be reduced to a pulp suitable for making paper. Refuse silk is indeed occasionally used with other things; but the greatest part of the Chinese paper is made from the inner bark of the bamboo and some other trees. The Chinese also make paper from cotton and linen rags; and a coarse yellow sort for wrappers is made from rice-straw. Only the second skin of the bark of the bamboo is used, which is beaten into a pulp with water. The Chinese can make sheets of a large size: the mould on which the pulp is made into paper being sometimes ten or twelve feet long, and very wide, and managed by means of pulleys. It is formed of fine threads of bamboo, as ours are of wire. To prevent the ink from running, the sheets are dipped into a solution of alum, which, as their ink is thicker than ours, is generally sufficient for the purpose, but sometimes fish-glue is mixed with the solution of alum. (Du Halde's 'China,' vol. ii., p. 415; Davis's 'Chinese,' chap. xvii.)

The Arabians, in the 7th century, appear either to have discovered, or to have learned from the Chinese, the art of making paper from cotton. They seem to have carried the art to Spain, and to have there made paper from linen and hemp as well as from cotton. ('Journal of Education,' No. 10.)

So far as concerns our own country, a manufacturer named Tate had a paper-mill at Hertford early in the 16th century; and another mill was established in 1588 at Dartford in Kent, by John Spelman, who was knighted by queen Elizabeth. Previously to this, and for some time afterwards, our principal supplies were from France and Holland. The making of paper in England had made little progress even so late as 1662. Fuller has the following remarks respecting the paper of his time:—"Paper participates in some sort of the character of the country which makes it; the Venetian being neat, subtle, and court-like; the French, light, slight, and slender; and the Dutch, thick, corpulent, and gross, sucking up the ink with the sponginess thereof." He complains that the making of paper was not sufficiently encouraged, "considering the vast sums of money expended in our land for paper out of Italy, France, and Germany, which might be lessened were it made in our nation." Thomas Watson, a stationer, by the introduction of foreign improvements in 1718, gave a great impulse to the manufacture of paper. Still, notwithstanding the great increase of demand and application of capital, it was much retarded by the heavy duty, of which we shall have to speak presently. So late as the middle of the last century, only very common paper, principally for wrapping, was made in Great Britain. It was not until 1770 that the celebrated Whatman introduced fine-paper making at his mill at Maidstone.

In the making of paper, any fibrous vegetable substance may be used: such as the inner bark of trees, the stalks of the nettle, the tendrils of the vine, the bine of the hop, wheat straw, flax straw, &c. Nothing however has yet been found to answer so well as linen, hempen, or cotton rags. The sweepings of the cotton-mills are also much used. Woollen cloth is not fit for the purpose, because it cannot be beaten into a suitable pulp, and also because it gives a hairy texture to the surface. Linen rags are the best of all for the purpose. The rags, however, of our own country do not constitute a fourth part of the quantity which we use in making paper. Italy and Germany furnish the principal supplies. They are imported in bags of about 4 cwts.; each bag being marked in such a manner as to indicate the quality of the rags which it contains.

In every paper-mill the first business is to sort the rags and cut them into small pieces. This is done by women, each of whom is provided with a large knife to cut the rags. Threads and seams are carefully put by themselves: if ground with the cloth, they would form specks in the paper. The rags, when cut, are thrown in to five or six different compartments of a large chest, according to their qualities. Only the finest linen rags are used for the best writing-paper, but cotton as well as linen rags are now used for printing-paper.

A good workwoman can sort and cut about a hundredweight a day. Hempen rags are used for coarse papers, and old cordage and tarred ropes for brown wrapping-papers.

The rags are now to be washed, which is done either with hot water in a fulling-mill, such as is used for scouring cloth, or they are subjected for some hours to the action of steam. Formerly they were half rotted to prepare them for being more easily torn and beaten into a pulp. But by this process the fibre was partially destroyed, and the texture of the paper materially injured.

Previous to the important discovery that chlorine possesses the property of destroying all vegetable colours, paper-makers could only bleach their rags by subjecting them to various washings in alkaline leys, and by exposing them to the dew and light; and after all their pains, they only obtained a paper so imperfectly white that they were obliged to mask the defect by tinging it with a shade of blue. But now, by the proper application of chlorine, either in the form of the simple gas or in combination with lime (chloride of lime), the colour can be perfectly discharged, and the paper rendered, if necessary, of the purest white. Objections have been justly made to the improper application of chlorine in bleaching paper. Sometimes it is applied in such quantity, or for such a time, as to injure the substance of the fibre; sometimes the paper, after it is made, is bleached with chlorine in such a manner that the ink turns brown; and there have been instances in which the colour has been nearly discharged altogether, leaving the sheet almost as it was before it was written or printed upon. It is now, however, generally admitted that chlorine, judiciously applied, is not in the smallest degree injurious to the paper, or liable, in any length of time, to alter the colour of the ink; although there is unquestionable proof that, unless skilfully managed, bleaching leaves the fibres less coherent than they were before.

The rags, after being washed, are subjected to the action of a revolving cylinder, the surface of which is furnished with a number of sharp teeth or cutters, so placed as to act against other cutters fixed beneath the cylinder. The rags are kept immersed in water, and subjected to the action of the cutters for several hours till they are minutely divided and reduced to a thin pulp. During this process a quantity of the chloride of lime or of chlorine gas is mixed with the rags, by which the pulp is rendered perfectly white. Until about a century ago, the rags were always pulped by means of stampers; but cutting-machines, introduced by the Dutch, greatly expedited the process.

The pulp, or *stuff*, as it is technically called, is now ready to be made into paper, which is done either by hand or by machine. On the hand-method, the stuff is put into a large vat, and is kept at a proper temperature either by a stove or by steam-heat; and the fibrous matter is held in suspension by a continual motion carried on in the vat by means of what is technically called a *hog*, or by other improved apparatus.

The paper is made with a *mould* and *deckle*. The mould is a shallow square frame covered with wire-cloth, and a little larger than the sheet intended to be made upon it. The wire-cloth is now generally woven in a loom like cloth, and makes no wire-marks on the paper; but the old fashioned wire-cloth consists of a number of parallel wires stretched across the frame, very close together, and crossed at right angles by other stronger wires about an inch apart. These thicker wires make the *wire-marks* of the paper, the stuff being there thinner than on the rest of the sheet. It was Baskerville who introduced the woven-wire moulds, in 1750; or rather, a beautiful edition of 'Virgil,' printed by him on paper thus made, was the means of drawing general attention to this improvement. The deckle is a very thin frame of wood which fits close upon the mould, and is required to retain the stuff on the mould and to limit the size of the sheet. The *dipper*, or *vatman*, inclining the mould a little towards him, dips it into the vat with the deckle upon it, and lifts it up again horizontally. He shakes it to distribute the stuff equally, and the water drains through the wire. He lays the mould on the edge of the vat, and takes off the deckle, which he requires to apply to another mould. After remaining two or three seconds to drain, the mould is taken by another workman, the *coucher*, who, having deposited the layer of pulp upon a felt, or piece of woollen cloth, returns the mould to the dipper, who in the meantime has made another sheet, which stands on the vat ready to be couched upon another felt spread over the former sheet. Thus the two workmen proceed till they have made a pile of sheets, called a *post*, consisting of six or eight quires. This post, with its felt, is placed in the *vat-press*, and subjected to a strong pressure to force out the superfluous water, and to give firmness and solidity to the paper. The pile is then removed from the vat-press, the felts are taken out, and the sheets pressed again by themselves. They are then taken from the press, and hung up, five or six together, in the drying-room.

The paper is now made, and only requires finishing. The greater number of the finishing processes are only required for writing-paper: common printing-paper and wrapping-papers being ready for packing up when dried. Writing-paper is dipped, five or six sheets together, into a tub of size, and afterwards pressed to force out the superfluity. It is then hung up again in the drying-room. Printing-paper is sized in the stuff. Every sheet is examined, imperfections are removed, and bad sheets taken out. A large pile of paper is then made, and pressed with great force to render the sheets quite flat and smooth. The pile is next taken down sheet by sheet, and another made, by which new surfaces are brought into contact with each other; and the pile is again pressed strongly. This operation, which is called *parting*, is done two or three times for the best papers. The paper is now counted into quires, folded, and packed up into reams. The size is made from skins and other animal substances, and is required to prevent the ink from spreading among the fibres by capillary attraction. Blotting-paper is not sized.

We now proceed to notice the machine-method of making paper—without which, the extension of cheap literature, and the wonderful development of the newspaper system, would have been almost impossible; printing-machines would possess insufficient material to print upon, had not paper-making machines kept pace with them. The history of these last-named machines is briefly as follows. Just at the close of the last century, M. Robert, a workman in the employ of M. François Didot, at a paper-mill at Essones, in France, invented a machine for making continuous paper; Didot set the apparatus to work; and Robert obtained 8000 francs from the government, and a patent for fifteen years. This was in 1799. In 1801 Didot came over to England, accompanied by Mr. John Gamble, who had resided some time in France. After sundry negociations, and the obtaining of two English patents, these patents were sold to Messrs. Fourdrinier. Messrs. Hall's establishment at Dartford, in Kent, was selected as the place for making the machines, under the special care of Mr. Bryan Donkin. It was in 1803 that the model of the first self-acting machine was set up at Frogmore, in Hertfordshire; and in 1804 that the system came successfully into work at a paper-mill at Two Waters. Since that year, a succession of beautiful additions and improvements have been made; although it is only just to mention that the main principles of the machine have all along remained nearly the same. Messrs. Bryan Donkin & Co. have devoted such special attention to this subject, that they have throughout been the chief makers of the machines: in the first ten years they set up 18 paper-machines; in the next ten, 25; by the year 1851 they had set up 191; and the number has since steadily increased. So far from these having all been intended for home use, more than half were made for foreign manufacturers: Germany being the best customer on the continent of Europe. It is proper to state that some of the matters connected with the early history of the paper-machine, both as to honour and profit, are still in dispute; and that so late as 1857, Mr. John Gamble, in a communication to the Society of Arts, protested against the way in which his name is generally omitted from among those who deserve credit or fame as introducers of the paper-machine. It is not often that an inventor, or the fosterer of an invention, lives to put in such a claim fifty-six years after the occurrences to which the claim relates.

We shall now briefly describe the operation of the paper-machine. The machine is constructed in such a manner as to imitate, and in some respects to improve, the processes used in making paper by hand; but its chief advantages are, that paper can be made of any size that can practically be required, and with a degree of rapidity which leaves the other mode of making it at an immeasurable distance. The pulp is first made to flow from the vat upon a wire frame, or sifter, which moves rapidly up and down so as to force the fine filaments of the pulp through the wire, whilst it retains any knots or other unsuitable matter. Having passed through the sifter, the pulp flows over a ledge in a regular and even stream, and is received upon an endless web of wire-gauze, which presents an uninterrupted surface several feet long. The wire-web moves forward with a motion so regulated as, taken in connection with the quantity of pulp allowed to flow upon it, to determine the thickness of the paper. At the same time a shaking motion is given from side to side, to the wire web, which assists in spreading the pulp evenly, and also in facilitating the separation of the water, which passes through the wire; by this means the pulp solidifies as it advances, and is at the same time prevented from flowing over the sides by straps which regulate the width of the paper. Before the pulp, now no longer fluid, quits the plane of wire, it is pressed by a roller covered with felt. It is next taken up by an endless web of felt, which forms an inclined plane, and gradually moving forward absorbs a further portion of the moisture. The pulp is now seized by a pair of rollers, between which it is pressed; and then it passes upon another inclined plane of felt, which conducts it to another pair of pressing rollers. The pulp is at length paper, and only requires to be made dry and smooth. To effect these objects, the machinery conducts it over the polished surface of a large cylinder heated by steam. From this cylinder it passes to a second, larger and hotter, and then to a third, which is still hotter than the second. After this it is subjected to the pressure of a woollen cloth, which confines it on one side while the cylinder smooths it on the other. It is then conducted by another roller to a reel, on which it is wound, perfectly dry and smooth, and ready to be cut into sheets for use. In two or three minutes the pulp, which is introduced upon the wire web at one extremity of the machine, is delivered at the other in the state of perfect paper. In printing-paper the size is commonly added to the pulp; but writing-paper is sized after the sheets are cut, as in hand-made paper.

In most of the paper-making machines a partial vacuum is produced under the endless wire-web by means of large air-pumps. The atmosphere is thus made to press upon the pulp, and the moisture is forced through the wire. Owing, however, to the change of stroke of the pistons, a uniform degree of vacuum cannot be maintained, so that the pulp receives various degrees of pressure, and consequently the paper is made of unequal thickness. To remedy this defect, by rendering the vacuum as uniform as possible, two patents were taken out in 1839; one to effect the purpose by substituting a revolving fan for the air-pump, and the other by using hydraulic air-pumps working on the principle of gas-holders, instead of the common ones.

Various patents have been taken out for improvements in parts of the machinery, or for other machinery to be applied in various stages of the process. One was taken out by Mr. Dickinson for an apparatus to separate the knots and lumps from the pulp, by making the pulp pass through the periphery of a revolving cylinder constructed of an endless spiral wire attached to metal bars. Other improved processes for the same purpose have been invented. A patent was taken out by Messrs. Towgood and Smith, the object of which is to apply the size to the paper as it comes in a continuous sheet upon the endless wire-web. The operation in this apparatus is performed by rollers, the surfaces of which are supplied with size, which is transferred from them to the newly-made paper as it passes between the rollers. Mr. Dickinson has a patent for uniting two layers of pulp in order to produce paper of an extra thickness. The combination of two or more sheets of pulp has been long employed in the making of thick drawing-paper and Bristol-board by the process called couching; but Mr. Dickinson's contrivance affords the means of doing it in a common paper-making machine. No attempt, however, can be made here to enumerate in detail the steps by which improvements have been introduced in the paper-machine; they are too numerous. Foreign inventors have done much in this matter. The names of Robert and Didot have already been mentioned; and we may also notice M. Canson, who was the first to apply suction-pumps to the machines; and M. Jequier, who devised a mode of making continuous paper with wire marks. Among English paper makers and machinists, the names of Brown, Crompton, Taylor, Barrett, Ibotson, Wilks, and Hollingworth may be mentioned as the introducers of valuable improvements in the continuous paper making. So wonderful is now the operation of the machine, that fine writing-paper can be made, sized with gelatine, dried, and cut into sheets, at the rate of 60 feet a minute in length, and 70 inches in width.

Varieties of Paper.—We shall now notice a few matters connected with the differences in the kinds of paper, without particular reference to the fact of their being hand-made or machine-made.

It may here be observed, that various wire-marks, or water-marks, as they are called, were formerly applied to paper to distinguish it. On the paper used by Caxton and the other early printers these marks consisted of an ox-head and star, a collared dog's head, a crown, a shield, a jug, &c. A head with a fool's cap and bells gave name to the paper called foolscap; and post paper seems to have derived its name from the mark of a horn, which was formerly carried by the postman, and blown to announce his arrival. Hand-made paper is now commonly marked with the name of the maker, and the date of the year when it was made.

The cutting of paper into sheets of any desired size is an operation which has been greatly improved within the last few years. The best paper is examined when made, to remove knots or specks, and to lay aside damaged sheets. It is then counted into *quires* of 24 sheets, folded, and put up into *reams* of 20 quires. If the paper is for printing, the continuous web made at the machine is cut into sheets of a certain size, without any particular regard to the fineness of the cut; but in the preparation of writing-paper, whether hand-made or machine-made, the cutting is very carefully attended to. Hence there are cutting-machines of two different classes, one to sever the web into sheets, and one to cut well-squared sheets of writing-paper. In the first of these kinds the paper is generally coiled round a cylinder into a substantial mass, and this cylinder, while rotating, is brought at intervals against a cutting edge in such a way as to cut through the paper. In the second kind much ingenuity has been shown; and it is certain that the remarkable cheapening of writing-paper since the introduction of the penny post has been greatly due to the adoption of machines, instead of hand-cutting, for the severance of the paper into sheets. In Black's paper-cutting machine, a sharp knife fixed to a rack is made to traverse laterally by the motion of the rack. The paper is laid upon a bed, and is adjusted by a screw spindle. A back-plate is hinged at its lower edge, so as to be brought by pinching-screws to a proper position for the paper to be cut rectangularly; and there is a screw to raise and lower the knife. Morgan's cutting-machine is intended to do the work with a small expenditure of power; the cutting-knife rotates on an axis, and the paper advances horizontally to meet it, like the action of a circular saw in timber-cutting. In Ullmer's machine there is a contrivance for imparting to the cutting-knife a diagonal movement, so as to enable it to make a draw-cut in an effective manner. There are many other paper-cutting machines, acting on similar principles, but differing in details.

Mr. Herring, in a recent work on the paper manufacture, while giving a list of the various sizes and names of paper, puts together the writing, drawing, printing, and wrapping papers, and then separates them simply into two groups, according as they are fine or coarse. The chief names and sizes mentioned by him are as follow:—

FINE PAPERS.

	Inches.		Inches.
Pot	15 by 12½	Printing demy	22½ by 17¾
Foolscap	17 ,, 13½	Medium	22 ,, 17½
Post	18¾ ,, 15¼	Printing medium	23 ,, 18½
Copy	20 ,, 16	Royal	24 ,, 19
Large post	20¾ ,, 16½	Printing royal	25 ,, 20
Medium post	23 ,, 18	Super royal	27 ,, 19
Sheet-and-third foolscap	23 ,, 13½	Printing super royal	27 ,, 21
Sheet-and-half foolscap	24½ ,, 13¼	Imperial	30 ,, 22
Double foolscap	27 ,, 17	Elephant	28 ,, 23
Double pot	30 ,, 25	Atlas	34 ,, 26
Double post	30½ ,, 19	Columbia	34½ ,, 23½
Double crown	30 ,, 20	Double elephant	40 ,, 26¾
Demy	20 ,, 15½	Antiquarian	53 ,, 31

The coarser papers present the following group:—

	Inches.		Inches.
Kent cap	21 by 18	Double small-hand	29 by 19
Bag cap	24 ,, 19½	Copy loaf, 38 lb.	21¼ ,, 16¾
Havon cap	26 ,, 21	Powder loaf, 58 lb.	26 ,, 18
Imperial cap	29 ,, 22	Double loaf, 48 lb.	23 ,, 16½
Double 2 lb.	24 ,, 17	Single loaf, 78 lb.	27 ,, 21½
Double 4 lb.	30 ,, 21	Lump, 100 lb.	33 ,, 23
Double 6 lb.	28 ,, 19	Hambro', 48 lb.	23 ,, 16¼
Middle hand	22 ,, 16	Titles, 120 lb.	35 ,, 29
Lumber hand	29 ,, 19½	Prussian lump, 200 lb.	42 ,, 32
Royal hand	25 ,, 20		

So numerous, however, are the sizes, thicknesses, and qualities of the various kinds of paper, cardboard, millboard, &c., that some of the largest wholesale dealers, according to Mr. Herring, keep in stock not much less than *two thousand* different kinds. Placing them under a few headings, without regard to size, papers are sometimes designated thus:—*Writing* paper, five kinds, namely, cream wove, yellow wove, blue wove, cream laid, and blue laid; *printing* paper, two kinds, namely, laid and wove; *wrapping* paper, four kinds, namely, blue, purple, brown, and whited-brown. In these various kinds of paper it is believed that England takes the lead of the Continent, except in two particulars: that *thin* French writing-paper is better than English; and that the French obtain a purer surface than the English, who often hide a dirty white by blueing it.

A few years ago careful experiments were made to determine the relative strengths of different kinds of paper; and the result was given in the last edition of the 'Encyclopædia Britannica.' In the following table the first column shows the kinds of the paper; the second, the weight in grains of a superficial foot; and the third, the weight in pounds upheld without breaking by a strip two inches broad:—

Bank post, very thin, sized	65 grains.	23 lbs.
,, thinner, unsized	48 ,,	13 ,,
Thick writing, machine-made	139 ,,	42 ,,
,, hand-made	143 ,,	60 ,,
Drawing paper, machine-made	217 ,,	55 ,,
Newspaper, sized at machine	113 ,,	39 ,,
Scotch bank-note paper	95 ,,	70 ,,
Strong cartridge paper	135 ,,	64 ,,
Pink blotting-paper	90 ,,	10 ,,

Among the varieties in paper-making may be mentioned Dickinson's double-faced paper, to be used either for lithographic or copper-plate printing, according as one or the other surface is selected; two webs of different kinds of pulp are placed one on another, and are pressed so as to unite them into a single sheet. *Laced* paper is now very much employed. The French have long made it, and applied it to ornamenting fruit-baskets, lamp-shades, print-borders, &c. About 1830, M. Rivière, a Swiss watchmaker established in London, obtained a patent for perforating thin metal plates; Messrs. De la Rue contrived a modification of the same apparatus for perforating pasteboard and card; and hence has arisen an extensive branch of ornamental paper-making, especially for *valentines*, the production of which is enormous. Plain-surface coloured papers are now largely made, for the use of bookbinders, printers, button-makers, confectioners, &c. The colour is applied by means of brushes, similar to those employed by paper-stainers; but the pigments are better, and more care is taken in laying on, smoothing, and finishing. Gilt, silvered, and coloured papers are prepared for decorative stationery, by chromo-lithography, surface-printing, block-printing, and woven-wire printing. The ingenuity of paper-makers has also been directed to the production of paper covered with real gold and siver; paper coated with bronze or imitation bronze; paper embossed and grained by means of engraved rollers, dies, and plates; paper varnished to imitate Morocco leather; paper enamelled, for the ground of fine satin paper-hangings, and for other ornamental purposes, by treating the surface with sulphate of barytes—a pigment reduced in price within a few years from 21*s.* to 6*d.* per lb.; paper extra-enamelled with Kremnitz white lead, for wedding-cards, &c.; paper with an opaline iridescence, prepared by Messrs. De la Rue; paper to which a kind of metallic granular surface has been given, for memorandum books; &c.

Much attention has been paid to the manufacture of paper which may frustrate the designs of forgers. The selection of a device or design for bank-notes, cheques, &c., the mode of engraving, the mode of printing, and the kind of ink, all bear immediately on this subject. The principle is this—to apply to the paper such a chemical agent that, if the ink be tampered with, the paper shall become discoloured and the attempt at fraud revealed. Mr. Stone, Mr. Barclay, Mr. Stevenson, Mr. Herapath, and other persons, have directed their attention to this matter; and the chemicals suggested for application are prussiate of potash, iodide and ferrocyanide of the same alkali, salts of copper, salts of manganese, starch, &c. One recipe is, for a ream of post, 1 oz. of iodide of potash, ¼ oz. of ferrocyanide of potash, and 1 lb. of starch. Any attempt to remove writing by chemical agents from paper thus treated would damage the colour of the paper itself. A paper has been read and a discussion has taken place on this subject before the Society of Arts during the present year (1860).

Of the practical applications of paper little need be said: these are for the most part sufficiently obvious. The amateur arts of papyrography, papyro-plastics, potichomanie, &c., are little more than ingenious modes of cutting out sheets of paper. We may mention, however, the bituminised paper tubes made by M. Jaloureau. He finds that when bitumen is mixed with chalk, and paper tubes are saturated with it, they become remarkably strong and durable, and are available as water-pipes.

Materials for Paper—A little attention must now be paid to the subject of the *materials* for paper, concerning which the manufacturers have lately had many discussions. Repeated attempts have been made to manufacture paper from straw, but it is only recently that any success has been obtained. One mill in the United States now makes 30 tons of this paper weekly. Wheat-straw is put into a large spherical boiler, and there boiled for 24 hours at 320° Fahr., a temperature obtained under great pressure. The straw becomes converted into a glutinous mass, which by further processes is available as pulp for paper. Dr. Collyer, in April, 1860, communicated to the Society of Arts the result of an elaborate series of experiments on the manufacture of paper from straw. He was led by his researches to recommend the following processes:—The straw is first passed between two rollers rotating with different velocities; this produces a trituratory action, which rubs out the knots and ears, and at the same time opens the straw out to a partially fibrous state. The straw is then exposed to the action of water heated by steam, and containing 3 ozs. of caustic alkali to the gallon. The apparatus is so arranged that the alkaline liquor can act over and over again upon the straw; and by repeated workings after this steeping, nearly all the gluten and silica are removed from the straw. The bleaching is effected by chloride of lime, with superheated steam. The making into pulp then ensues, and the manufacture proceeds as with rags. These operations, however, are quite tentative. All the straw paper hitherto made is unpleasantly crisp and brittle; and it has been found that the price of straw goes up considerably whenever the paper-makers create a demand for it. Nevertheless, two or three of the penny daily newspapers are printed on straw paper, and the experiment is felt to be worthy of further investigation.

Another kind of paper is Schlesinger's, manufactured of wood. Timber is cut by machinery into logs about eight inches in length. These logs are made to press against a rotating grindstone made of very rough stone, and well moistened with water. The wood is rubbed off in a state of fibrous pulp, which, either used by itself, or mixed in certain proportions with rags, is converted into paper. A mill for the manufacture of paper of this kind was opened at Bradford in 1854, the paper produced being chiefly wrapping, packing, cartridge, and other coarse kinds. The wood pulp is said to be obtainable at about 1*d.* per pound.

The increasing importance of obtaining a supply of rags for paper-making, and the restrictions placed by foreign governments on the sale of such rags to England, have lately recalled attention to projects long ago entertained. It is said that no less than 45,000 tons of linen rags, all collected by the *chiffoniers*, or itinerant ragmen, were used in France in 1859 in paper-making; and the paper-manufacturers of that country strenuously oppose any plan which might lead to an increased sale to England. Nearly all vegetable fibrous substances, as was observed in a former paragraph, can be converted into paper; but the problem is, whether such paper would be fine enough, strong enough, and cheap enough to compete with rag-paper. The so-called Chinese rice-paper consists of thin films cut spirally from the branches of a particular tree, the *Œschynomene paludosa.* There is in the British Museum a curious book, prepared by Jacob Christian Schäffer, a native of Ratisbon, about the year 1775. It describes the manufacture of paper from different substances, and the sixty leaves of which the book is composed are made of sixty different kinds of paper. The bark of the willow, beech, aspen, hawthorn, linden, and mulberry; the down of the catkins of the black poplar, and the silky down of the asclepias; the tendrils of the vine, the stalks of nettle, mugwort, and dyers'-weed; various kinds of leaf, fibre, and stalk; as well as straw, reeds, moss, lichens, wood shavings, sawdust, potatoes, and fir-cones—all were employed. The paper is in all the specimens of very inferior quality, both in colour and texture; but unquestionably the same materials would yield better results, if treated with modern skill and appliances. In 1854 the proprietors of one of our great newspapers offered a prize of 1000*l.* to the discoverer or inventor of any new kind of paper which, at a certain wholesale price, should possess a certain list of good qualities; but the desired standard has, we believe, never yet been reached. In the same year, the Treasury drew the attention of the Board of Trade to the scarcity in the materials for paper; and suggested that, in conjunction with the Foreign Office, the Board might possibly be able to obtain from British consuls abroad, useful information concerning vegetable fibre which would be available for this manufacture. It was mentioned that 2*d.* or 2½*d.* per pound might perhaps be the price which paper manufacturers would be willing to give for such materials. r. Lyon Playfair, on the part of the Board of Trade, stated that, after conferring with many eminent manufacturers, he had arrived at a conclusion that any new material must be obtainable at 1*d.* or 1½*d.* per pound, in order fairly to meet all the requirements. Much valuable information has since been obtained from British consuls abroad, and especially from Dr. Forbes Royle and Dr. Hooker, concerning fibrous plants in various parts of the world; and there is reason to hope that these researches will ultimately lead to beneficial results. In 1859 an attempt was made to establish a manufacture of paper from flax-straw and flax refuse, by means of a joint stock company, on the basis of a patent obtained by Mr. Houghton. Whether or not the process is a good one, the company itself has, we believe, not yet actually been formed.

Paper trade and duty.—Until 1837 the duty on paper was charged in two classes. That made whole out of old tarred rope, without extracting the pitch or tar, was considered as second-class paper, and paid only a duty of 1½*d.* per lb.; while paper made of any other materials was considered as first-class paper, and was charged with a duty of 3*d.* per lb. In the year above mentioned this distinction was abolished, and the duty on all kinds of paper was fixed at 1½*d.* per lb., which gave an immediate impulse to the trade. The effect of this change in augmenting the quantity used was soon shown. In round numbers, the quantity made in 1835 and 1836 averaged 78 million lbs. a year, whereas in 1837 and 1838 it averaged 91 million lbs. Foreign paper had not hitherto competed largely with home-made, because a Customs' duty had interfered with it. In 1857 and the two following years, the quantity of paper made in the United Kingdom was about 198, 193, and 218 million lbs. respectively; of which about one-twelfth was exported, and eleven-twelfths used at home. The average quantity made at each mill may be inferred from the following table, applicable to the year 1859:—

England	694	paper mills, of which	333	were at work in 1859.
Scotland	79		54	
Ireland	70		27	
	843		414	

Kent is the head-quarters of the manufacture; after which Hertfordshire and the neighbouring counties, Lancashire, and Devonshire. In Scotland, Lanark, Midlothian, and Aberdeen are the chief paper-making counties.

Few public subjects have been more discussed within the last few years than the propriety of removing the excise duty on paper. This duty, of 1½*d.* per lb. plus 5 per cent., after a few drawbacks for exportation, &c., yielded about a million and a quarter sterling of net revenue annually to the state; and Chancellors of the Exchequer, however favourable to the diffusion of cheap literature, have been unwilling to part with this easily collected tax. In 1853, the Society of Arts drew up a list of queries, and sent them to paper-manufacturers, wholesale stationers, manufacturers of paper articles, publishers, newspaper proprietors, and authors, soliciting opinions as to the modes in which the paper duty affected various branches of the public. Some of these queries were—Does the mode in which the duty is collected interfere injuriously with the process of manufacture, and in what way? Does it affect the quality and variety of the article manufactured? Does it limit materially the quantity of the supply? Do the excise regulations interfere with the rapid execution of orders? Does the mode of collection prevent the use of new materials? Does it place the manufacturer at a disadvantage in the market? Much valuable information was obtained in response to these queries. During the subsequent period of seven years (1854 to 1860 inclusive) great activity had been shown in the advocacy of the abolition of the duty, by various bodies, and through the medium of various publications. It is not now necessary to adduce the arguments used; for the tax is on nearly all sides admitted to be a bad one. In the session of 1860, Mr. Gladstone, as Chancellor of the Exchequer, moved the abolition of the duty, in connection with a very extensive financial scheme, including a commercial treaty with France, and a removal of Customs' duties from many minor articles. The bill for the abolition of the paper duty was passed by the House of Commons, but rejected by the House of Lords. The Customs' duty on foreign paper of 2½*d.* per lb., with 5 per cent. additional, has, however, been reduced to 1½*d.* per lb. with 5 per cent. additional, the same rate as the excise duty on the home manufacture, so that the importation is now unimpeded.

PAPIER-MÂCHÉ, the French term for a preparation of moistened paper, of which many articles are manufactured in England, France, and Germany. Such articles have been made in France for more than a century. In 1740 one Martin, a German varnisher, went to Paris to learn this manufacture from Lefevre. On returning to his own country, he was so successful in his exertions that his paper snuff-boxes were called, after him, "Martins." So much money went from Prussia to France in purchase of papier-mâché articles, that Frederic II., in 1765, established a manufactory at Berlin, which soon became very successful. Brunswick, Nürnberg, Vienna, and other German towns, by degrees commenced the manufacture, and it is now carried on to a considerable extent.

Two modes are adopted of making articles of this kind: 1, By glueing or pasting different thicknesses of paper together; 2, By mixing the substance of the paper into a pulp and pressing it into moulds. The first mode is adopted principally for those articles, such as trays, &c., in which a tolerably plain and flat surface is to be produced. Common millboard, such as forms the covers of books, may convey some idea of this sort of manufacture. Sheets of strong paper are glued together, and then so powerfully pressed that the different strata of paper become as one. Slight curvatures may be given to such pasteboard when damp, by the use of presses and moulds. Some of the snuff-boxes are made by glueing pieces of paper, cut to the sizes of the top, bottom, and sides, one on another, round a frame or mould. which is afterwards removed. Articles made of pasteboard have often a fine black polish imparted to them in the following manner: After being coated with a mixture of size and lampblack, they receive a coating of a peculiar varnish. Turpentine is boiled down till it becomes black, and three times as much amber in fine powder is sprinkled into it, with the addition of a little spirit or oil of turpentine. When the amber is melted, some sarcocolla and some more spirit of turpentine are added, and the whole is well stirred. After being strained, this varnish is mixed with ivory-black, and applied in a hot room on the papier-mâché articles, which are then placed in a heated oven. Two or three coatings of the black varnish will produce a durable and glossy surface impervious to water. Some of the articles now made in this way have their surfaces inlaid with mother-of-pearl; the shell is fastened down to the surface as a veneer, an immense body of varnish is laid on, and by rubbing the superfluous varnish from the pearl, the whole is brought to one common level, presenting a brilliant if not always tasteful effect. The better kind of tea-trays are shaped in or rather on iron moulds, the top of the mould giving the shape of the tray. The paper employed is a grayish, thick, granulated kind, made expressly for the purpose. The mould and paper are taken to a heated stove-room to dry, after three thicknesses have been applied; and this removal is repeated from ten to forty times, for the trays are made of thicknesses of paper varying from thirty to a hundred and twenty. The surface of the mould is greased in the first instance, to ensure the easy removal of the papier-mâché when of the proper thickness. A patent was taken out a few years ago for making papier-mâché panels for carriages, and considerable skill has been shown in the manufacture; but such panels are not much used in England, owing in part to the operation of the paper-duty.

The second kind of papier-mâché is, however, the more extensively made. It comprises that which is pressed into moulds in the state of a pulp. This pulp is generally made of cuttings of coarse paper boiled in water, and beaten in a mortar till they assume the consistence of a paste, which is boiled in a solution of gum-arabic or of size to give it tenacity. The moulds are carved in the usual way, and the pulp poured into them, a counter-mould being employed to make the cast nothing more than a crust or shell, as in plaster casts. In some manufactories, instead of using cuttings of made paper, the pulp employed by the paper-maker is, after some further treatment, poured into the moulds to produce papier-mâché ornaments. The use of ornaments made in the way just described is rapidly increasing. The carved and composition ornaments employed to decorate picture- and looking-glass frames are in some cases superseded by those of papier-mâché; but it is in the decoration of ceilings and walls of rooms and the interiors of public buildings that papier-mâché is found most valuable. Plaster and composition ornaments are very ponderous; carved ornaments are costly; but those of paper are light and of moderate price. In many of our theatres, in the House of Lords, in the Pantheon Bazaar, in the saloons of some of the splendid steam-boats recently built, and in numerous other instances where internal decorations are required, papier-mâché ornaments have been largely employed. Maps in relief are also occasionally made of papier-mâché.

A remarkable instance of the employment of papier-mâché is mentioned in Ersch and Grüber's 'Allgemeine Encyclopädie.' Near Bergen in Norway a church has been built capable of holding nearly a thousand persons. This building is octagonal without, but perfectly circular within. The interior of the walls, as well as the exterior of the Corinthian columns, is covered with papier-mâché. The roof, the ceiling, the statues within the church, and the basso-rilievis on the outside of the walls, are also made of this substance. The papier-mâche was made water-proof, and nearly fire-proof, by an application of vitriol-water and lime slaked with whey and white of egg.

An important modification of papier-mâché is that which is known by the name of *carton pierre*, or stone cardboard. This substance has been employed for half a century in France, but its use in England has been much more recent. It is a mixture of paper pulp, whiting, and glue. The mixture is pressed into moulds, then backed with paper, and removed to a drying-room to harden. The substance, when dry, is light, strong, and facile of application as an architectural ornament. It is now much used in obtaining casts of statuettes, busts, dead game, friezes, pilasters, foliage, &c. Messrs. Jackson and Graham have used this material very largely in the Army and Navy Club-house and other modern buildings.

Messrs. Bielefeld, among other inventions relating to papier-mâché, have introduced a mode of grinding fibrous and other materials into a consistence like that of putty; this is put into frames of a proper depth, rolled and compressed, heated and oiled, and finished by painting or varnishing. One among various compositions proposed is the following:—32 lbs. flour, 9 lbs. alum, and 1 lb. copper are mixed with 80 lbs. water; to these are added 15 lbs. resin, 1 lb. litharge, and 10 lbs. boiled linseed oil; the whole is finally ground up with 60 lbs. rag-dust or paper-makers' half-stuff.

PAPIST, an appellation derived from *papa*, "the pope," and which denotes a follower of the Roman Catholic church. That church calls itself catholic, which means "universal;" but as other Christian churches also style themselves "catholic," a distinction seems required to avoid confusion. The appellation Roman Catholic is generally used all over Europe to denote a follower of the church of Rome, in contradistinction to the followers of other Christian communions; but in Great Britain the words Papist and Romanist have been long in common use.

PAPYRIN. A name given to a modification of cellulose produced by immersing blotting-paper in strong sulphuric acid, then washing with water, and finally immersing for a few seconds in water containing a trace of ammonia. The paper thus acquires physical properties resembling parchment. [PARCHMENT, VEGETABLE.]

PAPYRUS. The name of a plant and the material made from it, especially that for writing used by the nations of antiquity. One of its names in the ancient Egyptian was *P-apu* (Select Papyri, Pl. xviii., l. 9.), which passed into Greek and Latin under the form *papyrus*; by the Hebrews it was called *gome*, which resembles the hieroglyphic *goma*, and Coptic *gomi*, a "book," or "volume." (Lepsius, Todt., lxxii. 162. 9.) The Greeks also called it Byblos (Herod. ii. 92.), or *deltos*, from the Delta, where it principally grew, and gave books this name (Winckelmann, ii. 96, 226, Dresd.). The term biblion, or bible, means in fact, a book or roll of papyrus. The plant itself, the paper rush, or *Cyperus antiquorum*, called *berd* by the modern Egyptians, distinguished by its tall prismatic, or triangular and tapering stem, growing to the height of about 10 feet, surmounted by a downy flower, appears to have been abundant in Egypt at the early period of the 4th dynasty. On monuments of the reign of Chephren, and Cheops, men are represented bearing bundles of this plant (Lepsius, Denkm., ii. 9–11), which they have gathered, or forming it into the light boats by which they crossed the marshes or the Nile (Lepsius, Denkm., ii. 12). The principal site of its cultivation was the alluvial ponds *uakh* (Lepsius, Denkm., ii. 74), where it is represented reaching the height of 10 feet in the Delta (Lepsius, Denkm., ii. 106 a). As early as the 5th dynasty, it appears in the hieroglyphics, either for the preparation of a colour for the eyes (Lepsius, ii. 22), or as designating the land of northern Egypt or the Delta, where it particularly grew (Ibid. ii. 47); but as the plant has gradually disappeared from Egypt, some naturalists have supposed that it was not indigenous, but introduced from the Niger or Euphrates, where it is still found native, and that it has become extinct for want of necessary culture. It has, however, been seen as late as the 19th century on the borders of the lake Menzaleh, the Phætnitic Uylarus, in Upper Egypt and in Abyssinia. Some think indeed, that the term papyrus comprehended two or three different kinds of reeds, such as the *Cyperus dives*, which is still cultivated in Egypt, and that the disappearance of the *Cyperus papyrus* is owing to the monopoly of the Roman contractors or publicani, who restricted its culture to a few localities. (Strabo, xvii. 550 c.) According to Pliny, it grew ten feet above, and two in the water, besides striking deep roots into the Nilotic mud, in the pools or marshes of the Sebynnitic and Saitic nomes.

The papyrus was one of those plants which the ancients converted to a multitude of uses. Its elegant and light flowers were woven into crowns, and neither the Spartan Agesilaus nor the Mithradates VI., of the line of Pontus, disdained to use it for that purpose, its pith or pulp was boiled and eaten, and considered the primitive food of Egypt, the root, on the contrary, was dried and used for fuel, the bark was manufactured into matting, sails, and ropes, bedding, and clothes. The priest used it only for sandals; and sandals of it remain to the present day in the collections of the British Museum. (Pliny, N. H. xiii. 11, 22; Strabo, xvii. 799. E). Boxes were also made of its stems, trimmed and tied at the ends and middle; and in an ark or box of papyrus, the youthful Moses was placed amongst the standing pools of papyri. At the time of Homer, it was used by the Greeks for rigging (Odys. xxi. 391), and Antigonus used for the cables of his fleet, papyrus grown in Syria. The ancient Greek name for the material was *bublos*, but it was not applied by prose writers to books (Lucan, iii. 222).

The invention of papyrus for boats was attributed to Isis, who searched for her husband Osiris in a bark of this material, which was said to be especially shunned by crocodiles, probably the reason why Moses was exposed in an ark of the same material by his mother. These boats are mentioned by Isaiah, Theophrastus, and Pliny. But the most remarkable use of this plant was for the manufacture of paper, *tams*, which appears in the hands of scribes on the earliest monuments (Lepsius, Denkm., ii. 6. 9. 11.) in square sheets or long scrolls, *sesht*. The process of manufacture, as described by Pliny, was to cut off both ends of the plant, the portion used was neither the outer bark nor the inner pith, but some twenty layers or pellicles under the rind surrounding the triangular stalk, those nearest the centre being the finest, which were separated by a needle. These were laid side by side upon a board, and other layers, philyræ, were placed at right angles on them, so as to cover them, and the whole cemented with Nile water, or more probably a fine glue. By continuing this process, it was possible to make the piece of any length and breadth required; and the whole was pressed, beaten with a hammer, and rubbed with tooth or shell, it was then pared, smoothed, laid in the sun, bound together and rolled out. The size and quality of this paper differs considerably, the greatest breadth being 1 foot 6 inches, or the lesser cubit; but some are not more than 4 inches, while the quality varies from a coarse and stringy to a silky material remarkably fine and smooth. The length was, of course, quite arbitrary, the longest pieces, such as the hieroglyphical ritual at Leyden, measuring 60 feet, while other portions do not exceed a few inches. The papyrus of the 18th dynasty is generally about 13 inches wide, and of a pale brownish-white colour; that of the 19th dynasty measures 9 and 11 inches, and is of a dark colour, those of the 20th are 14⅜, 11, 8, and 5 inches, and are of whiter colour and stouter texture; in the 21st, the papyrus is 8½ and 5 inches wide, and of dark colour. Some of the papyri of the subsequent dynasties are 1 foot 6 inches, or 1 foot, or 9½ inches wide, of whiter colour but coarser texture, and at the time of the 26th dynasty, the material is remarkably fine and white, but occasionally as narrow as 6 inches. The demotic contracts under the Ptolemies are written on a yellowish-brown papyrus of the average width of 11 inches, and about 20 long, while the Greek papyri, unde the Ptolemies and Romans, measure about 12½—14 inches wide; the rituals, 1 foot, 10 inches, 9½ inches, and these, as well as the Roman rituals, from 1 foot to 9½ or 4 inches, are of a stout and whiter material, not, however, so fine as those of the 26th dynasty.

The darkness of colour is probably owing to the greater age, those of the oldest period being generally the darkest and almost of a sienna colour, the material having carbonised with age, while the later are generally, but not always, white; but there can be no doubt that the contact of the rituals with the hot bitumen of the mummies has in many instances rendered the colour darker, the hieratic historical papyri, said to have been found in vases are, however, extremely dark. Papyri are found under various circumstances, but principally in connection with the mummies, as in their hands, under their arms, between their legs, or under the bandages stretched all over them like a shroud. They are generally, however, of a cylindrical form rolled upon themselves, the first page, of course, being outwards, and those of letters are sealed with a clay seal. The rituals are often placed in wooden cases, made in shape of Osiris, or Ptah Socharis Osiris, hidden in niches made for that purpose, or in the hollowed body of the deity, or else in a niche in the pedestal, so skilfully covered, joined, and painted as to elude detection by the eye. The historical and documentary papyri are said to be found in vases, boxes, and coffins.

The ink with which the Egyptians wrote on this material was an animal carbon, apparently mixed with oil; they used for the purpose a long rectangular palette or canon, from 1 ft. 8 to 9 inches long, and from 2 to 1½ feet in width, having two small cells or hollows which held a small quantity of red and black ink, the pens used were a thin, cylindrical and fibrous reed, called *kash*, the ends of which when split form a kind of natural brush. The writing is according to the nature of the document, the hieroglyphical in vertical lines of thin linear hieroglyphs, the hieratic and demotic in broader and thicker characters, generally about 10 lines to a page of 9 or 11 inches long, and in black and red characters. Compositions of the nature of books, are written with great care and regularity, official documents less so, and with characters of larger dimensions at the commencement. The religious compositions are ornamented with pictures or vignettes, traced with great delicacy, and sometimes brilliantly coloured with simple colours, and even gilded.

Considered as the books and documents of ancient Egypt, the papyri are of the greatest importance to the knowledge of the history and literature. They consist of Hermetic writings, religious and moral books, civil documents, and literary compositions in three kinds of writing, besides manuscripts in Greek of the highest literary importance. The most often repeated and extensively found, is the so-called ritual of the Dead, a copy or abridgment of which in one of the three writings was deposited with every mummy of consequence from the 18th dynasty to the Roman epoch.

This Book of Departure from the Day, and entrance into the future state, is a composition which can be traced as early as the 4th dynasty, or the pyramid builders, copies of which, more or less complete, exist in all the museums of Europe, there being probably 200 papyri relating to it in Europe. One of the copies at Leyden measures 60 feet, another in the British Museum still more; but the most complete example is the so-called ritual of Turin, written about the time of the Ptolemies, and published by Lepsius in the 'Todtenbuch.' The earliest examples are of the age of the 18th dynasty, or about B.C. 1500, with large cursive hieroglyphs written in retrograde lines; there are several of the age of the 19th dynasty, or about B.C. 1000, and one in the British Museum was made for an officer of the court of Seti I. In the subsequent dynasties the rituals are often abridged, a few of the principal chapters, chiefly those relating to the heart being given, and generally in the hieratic hand-writing which prevailed in the 26th, or Saite dynasty, which closed B.C. 525, when the hieroglyphs, if used, are smaller, but still neatly written, and the papyrus remarkably white and fine. Under the Ptolemies and Romans, mere extracts or short papyri containing excerpts of these sacred books were given; and under the Roman empire, the mummies had the allowance reduced to a single chapter. The rituals are divided into books, *shaa*, which are again subdivided into chapters, *zu*, and the whole comprised in volumes, *gama*. The sheets are called *sesht*, perhaps the Roman *scheda*, the pages *sesh*, the pictures, *skher*. These vignettes, one of which accompanies each chapter, are placed above the text, and represent the principal action of the chapter, the subject of which and the commencement, as well as the directions and especial words in the text are written in red ink, and are called *skher teshr*, or "rubric." The ritual was an inspired book, and was supposed to have been dictated and written by the god Thoth himself, and the collection of which it was composed assured to the soul a transit through the purgatory and other regions of the dead, the immortality of the future life, and its union with the body, the passage to the future judgment and acquittal, protection against decay and consequent transmigration, and directions for a variety of spells of a magical nature, especially for the preservation of the heart: the most remarkable part of the doctrine is the distinct enunciation of the immortality of the soul at the remote period of B.C. 2000, everywhere spoken of as the acknowledged dogma of Egyptian theosophy.

The first sixteen chapters commence with the invocation of Thoth to Osiris, and contain various prayers, and a formula for the preparation of the sepulchral work or little figures so often found in the tomb. The 17th chapter is an esoteric interpretation of the faith—the 18th to the 21st is the Crown of Justification, in which Thoth justifies the Osiris before or against different deities, in certain mystical regions. From the 22nd to the 26th are the different spells and incantations for the preservation of the heart, tongue, and other parts of the body. The 27th to the 42nd are destined to repel the various Typhonian animals that seek to destroy the body. The 43rd to the 63rd refer to the means for escaping decapitation in Hades, corruption and pollution, and the passage in the *makhen* or mystical boat over the river of Hades. Subsequent chapters refer to the exit of the soul from earth, its expedition into Elysium and passage of the Gates of the Sun. The most remarkable of these was found in the days of king Mencheres by the prince Hartetaf, on a brick under the statue of the god Thoth in Hermopolis. The 77th to the 87th contain the transmigrations or genesis of the soul under various types in the future state. The 89th, the union of the soul and body. Subsequent chapters refer to similar ideas. From 98 to 102 is a group referring to the mystical boat, a kind of Argo, the parts of which address the deceased, and require him to tell their names before it will move. The 110th is the Egyptian *Aahlu* or Elysium, where the deceased sows, irrigates, reaps, and eats of the divine corn of the Heavenly Egypt. The 125th contains the "great judgment," the appearance of the deceased before Osiris and the 42 demons, the negative confession of the sins he has not committed, the justification by Thoth, the weighing of his heart in the balance against the feather of Truth, the devourer of the wicked, the new birth, and metempsychosis. Each part of the Hall calls out to him to tell its name before it will allow him to proceed, and the deceased then escapes the pool of fire or Phlegethon, the subject of the 126th chapter. The subsequent chapters refer to the passage of the Empyreal gateway, and the admission into the boat of the sun in which that luminary circulated through the liquid ether or Celestial Nile. Other chapters contain miscellaneous information; 137 is to restore the vital warmth; 141, 142, the knowledge of the names of the gods; 145, 146, the passage through the mystical doorways of Osiris guarded by demons, whose names the deceased has to declare. In the 152nd, the deceased enters his new mansion and drinks the waters of Nu, or life; the 154th is to preserve the soul from transmigration. Seven others give instructions for the amulets placed on the throat of the mummies; and the last, 162, for the placing of the coffin of the dead so as to be blown upon by the four winds. The ritual closes here, but at the time of the Turin ritual three supplementary chapters, 163-165, were introduced, of mythical import, referring to the worship of Amen Ra.

Besides the ritual other religious papyri are known, one the book of the Lamentations of Isis over her brother Osiris, the other the passage of the sun through the eleventh hour of the night, chiefly found with the mummies of the priestesses of Amen Ra in the age of the XX and subsequent dynasties at Thebes, and a hymn to the Nile.

The hieratic civil and literary papyri are equally interesting and important for the knowledge of the chronology and history of the country. These papyri are known under the names of their possessors, as the Prisse, Sallier, Anastasi, D'Orbiney, and Abot Papyri. Of those as yet published, the most remarkable are the Hieratic canon of the kings at Turin, unfortunately much mutilated, which originally contained a list of kings till the 19th dynasty, with the dates of their reigns, and a chronological introduction; the Prisse Papyrus, consisting of a book of moral instruction written by Ptahhetp, an officer of the 5th dynasty, and the oldest known papyrus; the I. Sallier, containing an account of transactions between the Hykshos king Apapus, and the Egyptian monarch Taakan of the 17th dynasty; the II. Sallier, the instructions of Amenemha I. of the 12th dynasty to his son Usertesen I.; and those of Sakarta to his son Papi on his return from the college at Silsilis, the IV. Sallier, an Almanac of fasts and festivals, with the religious reasons for the same, and the luck or misfortunes of each day; the D'Orbiney Papyrus, the romance of the two brothers written by Enna for the young prince Seti II. in the reign of Merienptah, a kind of novel, the plot turning on the misconduct of the wife of the eldest, the death of the younger, his revival and metamorphosis into a bull, and persea trees; the III. Sallier, or poem of Pentaur celebrating the exploits of Rameses II., against the Khita, and the grand triumph of Egypt over that people. Besides these which are literary, several documentary hieratic papyri remain, as those at Turin, dated in the reign of Thothmes III., Amenophis II., Rameses II., III., V., VI., the contents of which are as yet unpublished, and the Abot papyrus dated in the 16th year of Rameses IX., containing an account of the violation of certain royal tombs and the examination by the police. The Anastasi papyri appear to be copies of correspondence and instructions entered on the Egyptian patent rolls. In Sallier I. are ten letters of Ameneman, and one of Pentaur, about agricultural affairs, the advantages of learning, and instructions. I. Anastasi describes a journey in Palestine, III. Anastasi miscellaneous matters addressed by Amenemap to Pinebsa, giving an account of a military life. IV. Anastasi admonitions and other affairs, V. VI. VII. VIII. of the same series, letters and miscellaneous entries about judicial and other matters. A series of papyri at Leyden refer to similar matters, or magic. At Berlin a papyrus contains the receipts of an Egyptian physician.

The demotic or enchorial papyri consist principally of contracts for the sale of lands, houses, mummies, and tombs, commencing in the reign of Psammetichus I., B.C. 850, and continuing till the reign of Nero; besides which, there are in the same handwriting, memoranda, accounts, letters, translations of fragments, or later rituals by the Gnostics, Basilidians, or Valentinians, occasionally accompanied with valuable interlinear translations and words in Greek. They are chiefly important for the light they throw on the chronology of the Persians and Ptolemies, and on the changes which the language underwent at a later period. Two Phœnician papyri have also been found in a tomb of the Thebaid.

The few Coptic papyri consist principally of portions of the Old and New Testament, religious works, deeds and donations to monasteries at Gemi in the Thebaid. There are no early Arabic papyri, but this language is found in the Neskhi character, probably written in recent times on old material.

Nor are the Greek papyri found in Egypt less important; and recent discoveries have not only added considerably to the stock of Greek literature, but excited hopes of finding still greater treasures. The 150 papyri found in the vicinity of the Serapeum of Memphis have revealed the inner life and government of that temple—the mode of transacting public business, the administration of justice, the value of commodities, the state of the chancery of the Ptolemies, the rules of the religious orders, and many other curious particulars connected with the history of that temple. [SERAPEUM.] Those exhumed from the ruins of Thebes have also been of great interest, throwing considerable light upon the history of the place, especially the sale of the mummies, liturgies, and houses, the quarrels of the various classes of undertakers and others in that declining city. Besides these, letters of private individuals, advertisements for runaway slaves, a treatise on astronomy, a horoscope, and a treatise on grammar, with extracts from lost authors, and other miscellaneous writings have been found. The discovery of a book of the 'Iliad,' and of two lost orations, and portions of two others of Hypereides, have proved what important manuscripts in this material may come from the Theban tombs. The Psalms of David, in uncial characters, on papyrus, in the form of a book, have also been found in Egypt.

Although there is no doubt from the mention of papyrus, either in its natural or manufactured state, by Homer, Alcæus, Æschylus, Herodotus, and Plato, that the Greeks were acquainted with its use at an early period, yet it is doubtful if it was universally employed, notwithstanding the spurious letter of Sarpedon, said to have been written from that monarch when at Troy, and sent to Lycia. It appears from an Athenian inscription that a sheet of papyrus, *charta*, in the days of Pericles, cost 1 drachm 2 obols, or about 1*s.* 1¼*d.*, which, taking the value of money at that period as four times greater than at present, amounts to about 4*s.* 6*d.* [Rhangabé 'Ant. Hell. I.,' 1842, No. 56—59; Egger, 'Rev. Contemp.' 1856, p. 171.] Probably the statement of Varro is substantially correct, and it was not much in use till the time of Alexander the Great—before which period the Greeks used palm-leaves, linen, lead, or wax. Among the Ionian Greeks *diptheræ*, or skins, appear to have been anciently employed, for they gave this name to papyri. At the time of the Ptolemies papyri and books were exported from Egypt, but the trade was stopped by the rivalry of the kings of Egypt and Pergamus—Ptolemy Epiphanes V. and Attalus, or Eumenes II., in whose reign the grammarian Crates is said to have invented *pergamena*, or parchment, or rather to have substituted its use, this material having already existed long before in Egypt—rolls of brown leather of the 14th, and of white leather or parchment of the subsequent dynasties existing in the collections of the British Museum of nearly 1000 years older than the parchments of the kings of Pergamus.

The use of papyrus in Rome dated from the earliest period, the books of Numa and the Sibyl were said to have been made of this material, but Varro, in a passage controverted by Pliny, states that the paper was first invented long after, in the days of Alexander the Great. It is clear, however, that it was in use in European and Asiatic Greece, and consequently Magna Græcia, long before. According to other authorities it was raised in Apulia and Calabria, and even in the marshes of the Tiber, in the vicinity of Rome; but there appears to be some doubt whether the Romans manufactured paper at Rome or merely improved and adapted the raw papyri exported from Egypt. In the days of the empire various kinds of papyri then in use were named from their size or fineness. The Romans prepared their paper with greater care, and sized it with a paste of fine flour stirred in boiling water with a few drops of vinegar, and some leaven, which was filtered and kept for one day; after sizing it was beaten with a hammer and sometimes sized a second time, pressed and smoothed. The names of the principal kinds were the *charta Augusta*, 12 inches broad, of a fine and white quality, anciently called the *hieratica*, because used for religious purposes, rather too thin for books, and used only for letters, hence called *epistolaris*; the *Liviana*, named after *Livia*, was the second quality; the third quality was the *amphitheatrica*, so called from being made near some amphitheatre, of 9 inches breadth, being beaten out from an Egyptian papyrus of 8 inches; an improved kind called the *Fanniana*, was prepared by the grammarian Rhemmius Fannius Palæmon, in the reign of Claudius I., 10 inches in width, and very fine, and capable of being written on both sides; the *Claudia*, invented by the same emperor, was 13 inches wide, and underlaid with a second layer; besides which there were the *emporetica*, or warehouse paper, for packing, of 6 inches; the *saitica*, made either of coarser or old material, and narrow; the *tæniotica*, very coarse, sold by weight; and other qualities and kinds as the *Thebaica*, *Carica*, *Memphitica*, named from the places where produced; the *Corneliana*, said to have been called after Cornelius Gallus; the *regia*, or royal, finer, but not large; and the *macrocollus*, larger than 13 inches. The quire, *scapus*, consisted originally of twenty sheets, or *plagulæ*, but was afterwards reduced to ten. The defects were roughness, spots, and gaps. The length of the writing on the pages was narrow, and the Herculaneum papyri do not exceed 4 inches; the writer used an ink made of soot, of pine-wood, burnt pitch, and resin, and special writers, called *chrysographi*, wrote gold letters; all wrote with the *calamus*, a Carian or Egyptian reed, on blind lines, *alokes*, generally on one side only, the back being generally stained with saffron or cedar-oil. The writings or books were rolled up upon a stick, like the Egyptian, into a cylindrical form—each cylinder was called *volumen*; and those of *Herculaneum* have the stick, *bacillus*, or the *umbilicus*, concealed in the rolls: at each end was a projecting knob, *cornu*; the edges were coloured black. Volumes were often placed in purple leather cases, called *sittybæ*; and the title of the roll, *titulus*, was written on a small strip of papyrus or parchment, *lorum*, in letters of a light red colour,—besides which, a portrait of the author was sometimes drawn on the first page of the roll. The titles of works were suspended to the door-posts, *columnæ*, of the booksellers, *librarii*, who formed an important class. Books were not very dear: a copy of the first book of Martial's 'Epigrams' sold for 5 denarii, or about 4*s.*, in the author's lifetime. The Alexandrian trade in books was very great; and nothing astonished Hadrian more on his visit to that city than the activity of the paper manufacture at Alexandria, which formed one of the staples of Egyptian commerce, which is mentioned by Philostratus, A.D. 244; and the pretender to the empire, Firmus, A.D. 272, boasted that he could feed his army off the papyrus and glue of his paper manufactory. The Alexandrian papyrus is mentioned by St. Cyril, A.D. 409, and a Latin deed of sale is known of the same century, found at Philæ. St. Jerome in this century mentions its use as universal. The use of this material continued to be universal in the following century, and there remains of this age the homilies of St. Avitus, A.D. 525; the charters of Ravenna, of A.D. 552; the homilies of St. Augustine, written on papyrus with sheets of parchment introduced; and fragments of Josephus. The most remarkable event of this age is the abolition of the paper duty by Theodoric, recorded in the pompous and flowery panegyric of Cassiodorus, A.D. 562. It is also mentioned in this century in the legend of St. Eugendus, and by Gregory of Tours, as exported from Alexandria. The Greek charters of Mauricius and Heraclius, A.D. 606–616, and the Latin of Dagobert I., A.D. 690, show its use in the east and west in the 7th century; the bull of Pope John VIII., A.D. 876, brings its use down to the 9th; and in Italy it continued to be used till the 11th or 12th, the latest known document being the bull of Paschal II. in favour of the see of Ravenna, but Eustathius, A.D. 1170, speaks of papyrus as extinct in his days; and it appears to have been quite superseded by the use of cotton-paper, *Charta Bombycina*, or *Damascena*, introduced by the Arabs from Asia, of which they obtained the knowledge in A.D. 704, according to some authorities, but no

Arabic paper manuscript bearing a date older than about A.D. 950 is known. Some indeed assert that the so-called papyri of these later centuries are really made of bark, and are a kind of charta corticea.

The most remarkable of the Roman papyri are the 1756 rolls, and fragments found in an excavation of Herculaneum, about A.D. 1753, in a book case in a small room in a house, utterly reduced to carbon, and twisted so as to resemble ram's horns, by the effects of the eruption of Vesuvius. They were at first believed to be mere billets of carbon, but letters having been observed on some, attempts were made to unrol and decipher them. The first attempts to unroll them were made by Paderni, who in 1755 incised them to the centre in two opposite places of the cylinder so as to reveal two pages, but otherwise to spoil the best papyri. The first succesful attempts were made by Piaggi in 1758, and since his time no improvement on his system has been made, the attempts of Lapira, Davy, and Sickler, being equally unsuccessful. The process of Piaggi still practised at Naples, is to lay the papyrus in a convex trough on cotton supported by two uprights of wood, which lower at the pleasure of the unroller; the trough is suspended by a band passing over it at each end, and attached above: the outer portion of the papyrus is slightly saturated with gum or glue, and the layer of writing detached with a needle, and as quickly as detached fixed by the back on a layer of gold-beater's skin placed vertically; a third band passes in the middle between those of the ends, and is attached to the gold-beater's skin which is drawn up with the pages attached as the operation proceeds. After a few pages have been unrolled, the skin is cut off and the pages handed to the artists who draw and engrave them, they are then passed to the interpreters who collate and transcribe them. The process is one requiring the greatest care, experience and patience, and the progress is necessarily slow, not more than about an inch can be unrolled in four or five hours, and it took four years to unroll thirty-nine pages of Philodemus on music, and one year and a half to perform the same operation for twenty-nine pages of rhetoric. When unrolled they are framed and glazed, and published. The work proceeds but slowly, owing to the interest taken in them having diminished since their discovery, and the contents not having had the literary importance that was expected. The rolls were in the library of an epicurean, and consist of philosophical disquisitions, chiefly by the philosophers of that school; there is one treatise by Epicurus himself on Nature, another by Chrysippus on Providence, several by Philodemus on Music, Morals, and other subjects, and others by Colotes, Carniseus and Polystratus. The papyri with latin texts are differently prepared, and present still greater difficulties to unroll. Neither the dimensions nor the fabric of these correspond with the description of Pliny, and it may be generally remarked that the monuments and literature of the ancients rarely agree. The breadth of the papyri at Herculaneum is from 8½ to 12¾ inches for that of the Greek, the Latin are wider; the pages are quite black, and the letters only distinguishable in a favourable light by the greater intensity of colour, or by their polish. From the similarity of the letters it is evident the rolls were new. The space occupied by ancient libraries of these rolls appears to have been considerable; from the portion of the 'Iliad' found at Elephantine, 8 feet long and 10 inches wide, it appears that a copy of the works of Homer would require 41 such rolls. In the Alexandrian library, a separate room contained his works and those of his commentators in 1000 rolls. The libraries of the New Museum at Alexandria, and of the Serapeum have been estimated at from 54,000 to 700,000 such books or rolls. At Rome the first public library was that of Asinius Pollio, in the time of Augustus; some private individuals possessed magnificent libraries, and that of Epaphroditus, the grammarian of Chæronea, who lived from the reign of Nero to that of Nerva, had 30,000 rare books in papyri. The rooms which held these papyri were probably small, and when required for reading, a few were carried out in cylindrical boxes, *cistæ*, of bronze, standing on three legs with a vaulted cover, and placed on the floor beside the reader. The rolls stood vertical, and were taken out of the box by a strip of parchment attached. The reader fixed one end by his chin, unrolled as far as he required, and then held the roll with both hands. The first pages were called *protocolla* or protocols, the last *eskatocolla*. So important was the due supply of paper to the Roman scribes and public, that a deficiency in the reign of Tiberius gave rise to a riot.

The manufacture, for the sake of verifying the statements of Pliny, was revived in the last century. Its existence in the vicinity of Panormus at a farm called the Massa Papyreti, had been already mentioned by Gregory and by Hugo Falcandus, at a place called Papero, and in the pools of the Liane, near Syracuse, where it was discovered by the Cavalier Landolina, and a coarse stout papyrus, inferior to the ancient, produced from it, small quantities for curiosities being made to the present day. It was introduced from Egypt under the reign of one of the later tyrants of Syracuse.

The extreme value obtained by papyri, some extraordinary manuscripts having fetched from 90*l.* to 200*l.*, and all of them being a highly prized class of antiquities, menaces these ancient rolls with destruction. The Arab fellaheen, who dive into the cemeteries of Gizeh and Gournal, tear into pieces "these frail rivals of the pyramids," as they have been called, and for the sake of obtaining greater sums from the ignorance of travellers, are accustomed to make out of the unfortunate fragments fictitious rolls of papyri. They make a core or body of blank papyri, or of the dried stem of an ancient plant found in the sepulchre, and then glue over this cylindrical mass fragments of one or more broken papyri, the writing outwards in an admired confusion, tie the whole with a strip, and seal it with a clay seal bearing the impression of a scarabæus. It is painful to think how many Egyptian and Greek manuscripts of the highest value to science and literature have been in this way destroyed.

The extremely brittle condition in which Egyptian papyri are found, renders it impossible to unroll them in their actual condition without injury, but they regain their elasticity by the application of cold or hot water, or exposure to damp, and still better by carefully steaming them in a covered vessel; those that have much oil or bitumen require the application of alcohol to separate them more easily: they should then be unrolled and laid down, if only written on one side, on drawing-paper, and fixed with a paste containing alum or a slight quantity of corrosive sublimate to prevent the ravages of insects. Formerly they were unrolled on a gauze and glued at the edges, and gently pressed with linen, but it is preferable to mount them as prints. When they are only endorsed in a few places, it is merely necessary to leave the endorsements not mounted, and place over them goldbeater's-skin or tracing-paper for protection. At Leyden, the papyri are fixed on tissue paper made transparent by glue, and they are rolled up; those in the Vatican are pasted on pages of cloth; those of Paris are glazed or fixed on thin but compact pasteboard; those in the British Museum are mounted in frames, or in separate pages of pasteboard and glazed. The custom of rolling up papyri is objectionable, owing to the fibres splitting with the unrolling and injuring the writing. Facsimiles of hieroglyphic hieratic, demotic, Greek, Latin, and other papyri have been published at various times, exhibiting the palæography, textures, size, and other peculiarities of these rolls.

(The principal works to be consulted are, Guilardinus, *Papyrus*, 12mo, Madrid, 1667; Mabillon, *De Re Diplomatica*, i. c. 8, p. 38 and foll.; Montfaucon, *Palæographia Græca* i. 2, p. 13 and foll.; Caylus, *sur le Papyrus*, *Mem. d'Acad.* xxvi., p. 267; Jomard, *Descr. de l'Egypte*, iii., p. 117–118; Winckelmann, ii., Bd. l.; Goodwin, C. W., *Cambridge Essays*, 1858, p. 226; *Library of Entertaining Knowledge—Egyptian Antiquities*, ii. c. 7; De Rougé, *Revue Contemporaine*, xxvii., p. 389; Chabas, *Revue Archeologique*, 1857; De Rougé, *Rev. Archeol.*, 1852; *Moniteur*, 7 et 8 *Mars*, 1851; Hincks' *Cat. of Eg. Man. Trin. Coll. Dubl.*, 8vo, 1843; Goodwin, Græco-Egyptian work on Magic, 8vo, 1852.)

PAR OF EXCHANGE. [EXCHANGE.]

PARA (coin). [MONEY.]

PARA. A prefix sometimes used in chemistry in naming compounds which either in properties or composition resemble the body to which it is attached, but differ from it in some other respects. Thus paracyanogen is a body of the same composition as cyanogen, but differs from the latter in properties. Such compounds will generally be found under the name to which the prefix is added.

PARABANIC ACID. [URIC ACID.]

PARABLE (παραβολή, "a comparison or similitude"), is defined by Bishop Lowth as "a continued narrative of a fictitious event, applied by way of simile to the illustration of some important truth." ('Prælect.,' x.) It is a species of fable, and differs from the apologue by narrating events which, though fictitious, are not impossible to have happened. [FABLE.] This mode of instruction is of great antiquity, especially among the eastern nations. In the Old Testament we have examples of it in the parable of Nathan to David (2 Sam., xii. 1-9), in that of the woman of Tekoah (2 Sam., xiv. 1-13), and repeatedly in the writings of the prophets (Is., v. 1-7; Ezek., xv., xvi., xix., xxiii., &c.). The parable of Jotham, which is often spoken of as the most ancient parable in existence (Judges, ix. 7-15), is properly an apologue. In the New Testament parables form a most marked feature of our Saviour's teaching. (See the gospels of Matthew, Mark, and Luke.) Lowth lays down as the essential qualities of a parable, that the image must be well known and applicable to the subject, and its meaning clear and definite; it must be elegant and beautiful in itself; all its parts and appendages must be perspicuous and pertinent; and the literal must never be confounded with the metaphorical sense.

Many of the Scripture parables are accompanied by an explanation, which, of course, fixes the sense. Where this is not the case, the intended meaning must be gathered from a consideration of the subject-matter of the parable itself, the context in which it occurs, and the circumstances under which it was uttered.

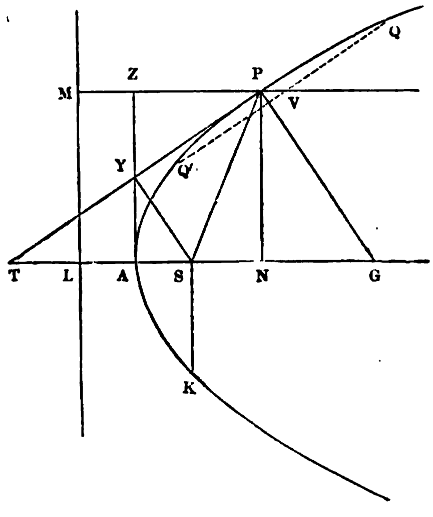
Besides its usual signification, this word is employed in the Scriptures in the following senses:—a proverb, a famous saying, a thing darkly or figuratively expressed, and a visible type or emblem.

PARA'BOLA. The probable origin of this name, as applied to one of the conic sections, may be seen in RECTANGLE. As in the case of the other CONIC SECTIONS [ELLIPSE and HYPERBOLA], we shall here give a small collection of the most remarkable properties of this curve.

1. Let a point P move in such a way that its distance SP from a fixed point S is always the same as its perpendicular distance PM from a given line ML. This point P describes what is called a *parabola*.

2. The line LS, perpendicular to LM, produced, is the *axis*, or *principal* diameter; and any line PV parallel to it is called a *diameter*.

The point S is the *focus*, and the line LM the *directrix*. The ordinate SK drawn through the focus is called the *semi-latus-rectum*, and double of it is the *latus rectum*. The same phrase is used for the ordinate drawn through the focus of an ellipse or hyperbola.



3. SA is equal to AL, and SK to twice AS.

4. If an ellipse be described with the vertex A and the focus S, the farther the centre is from the point S, the more nearly will the part of the ellipse which falls within any given ordinate PN coincide with the corresponding part of the parabola: and the same of an hyperbola drawn with the vertex A and focus S. And a parabola may be considered as an ellipse or hyperbola with a given focal distance AS, and a centre at an infinite distance.

5. The tangent PT bisects the angle MPS, and SP is equal to ST, and AN to AT. The line SY drawn perpendicular to the tangent from the focus always meets PT in a point of the tangent drawn through A.

6. If the *normal* PG be drawn perpendicular to PT, then SP is equal to SG, and NG is always equal to twice AS.

7. The square on PN is equal to four times the rectangle under AN and AS.

8. The area ANP is two-thirds of NZ, the rectangle under AN and NP.

9. If QQ' be drawn parallel to PT through any point V of the diameter PV, QQ is bisected in V, and the square on QV is equal to four times the rectangle under SP and PV.

10. The square on SY is equal to the rectangle under AS and SP.

In applied mathematics the parabola was formerly of great importance, both as being the curve in which a comet was supposed to move, and as that in which a cannon-ball or other projectile would move were it not for the resistance of the air. It is still sometimes used as the approximation to the elongated ellipse in which a comet moves. For the more accurate investigations which deduce the real path of a projectile, see GUNNERY.

PARABOLIC REFLECTOR. It is well known in CONIC SECTIONS that lines joining the foci and any point of the curve, make equal angles with the tangent at that point; hence by the law of REFLEXION if the surface of a mirror be formed by the revolution of a conic section about its axis, a pencil of rays incident upon its surface from either focus will, after reflexion, converge to or diverge from the other focus. Mirrors in the form of a parabola are used in reflecting telescopes, and in light-houses; but in the former the incident and in the latter the reflected is the parallel pencil of rays. The conjugate mirrors used for illustrating some of the phenomena of radiant HEAT, are of this kind, and such mirrors are also being introduced for conveying fog and other signals by means of sound.

PARABOLOID. The simplest form of this surface is the paraboloid of revolution, made by the revolution of a parabola about its axis. For the other meanings of the term, see SURFACES OF THE SECOND DEGREE. The solidity of the part of the paraboloid described by the revolution of APN [PARABOLA] is always half that of the cylinder described by AZPN.

PARACENTRIC, or "towards the centre," a term sometimes used, as in paracentric velocity, which means the rate at which a moving body approaches a certain centre without reference to the rate at which it moves in space.

PARACHLOROBENZOIC ACID. [BENZOIC ACID.]

PARACHUTE, a French word, signifying a means of preventing a fall. The first part of the word, *para*, is perhaps of Greek origin; the second part is the French word *chute*, a fall, which is of Latin origin.

A parachute is a machine attached to a balloon, and is intended to convey the aëronaut gently to the earth, in case of an accident happening to the balloon. It is in shape like an umbrella, and its construction may be understood by supposing the umbrella to be large and strong, to be provided with ropes or stays fastened to the extremities of the whalebones, and brought down to the handle, where they must be fixed, so as to prevent the umbrella from turning inside outwards. Instead of the stick, suppose a metal tube to be fixed in the centre, with a rope passing through it, attached by its upper extremity to the balloon, and by its lower end to a tub or car. This machine is a parachute: while ascending, it will be like a closed umbrella, but it may at any moment be detached from the balloon by cutting the end of the rope which is tied to the car; the resistance of the air will then cause it to expand, and will at the same time retard the velocity of descent.

The idea of using such a machine to break the fall from a high place is not new: it has been frequently experimented with; has been found utterly useless for any desirable purpose; and has caused the death of many who have attempted to descend by its means.

Three formulas have been given for calculating the velocity of descent of a parachute. They are—

$$26\sqrt{\frac{w}{d^2}}=v$$

$$28{\cdot}28\sqrt{\frac{w}{d^2}}=v$$

$$32{\cdot}98\sqrt{\frac{w}{d^2}}=v$$

in which w is the weight in pounds avoirdupois; d, the diameter of the parachute; v the number of feet fall per second.

According to the first of these, if a parachute be 50 feet in diameter and weigh 529 lbs., it will fall 11·96 feet in a second; according to the second, the fall will be 13·01 feet; according to the third, 15·17 feet: the truth may lie between.

In these three cases, the shock felt on landing would be nearly equal to that caused by a leap from heights represented by the following three formulas respectively:—$10{\cdot}5\frac{w}{d^2}$; $12{\cdot}4\frac{w}{d^2}$; $16{\cdot}9\frac{w}{d^2}$; being, under the given circumstances, something less than 2 feet 3 inches, 2 feet 8 inches, and 3 feet 7 inches: a fall, therefore, of two or three thousand feet would almost certainly be fatal.

PARACHUTE LIGHT is a description of light-ball invented by Captain Boxer, R.A. It consists of two tin hemispheres, one of which is filled with light ball composition, and has a lid soldered on to it, and four fuse holes made in the convex part through which the composition burns; and the other hemisphere contains the calico parachute folded up—the calico parachute is attached by wires to the hemisphere containing the composition. The whole is placed in a paper-shell containing enough powder to burst it, and is fired from a mortar. The fuse is timed to burst it when at the greatest height. The parachute being then liberated supports the hemisphere containing the composition in the air, which burning out of the fuse-holes throws a strong light on the ground, by which an enemy's working parties and movements during the night may be discovered.

PARACYANOGEN. When cyanogen is obtained by heating bicyanide of mercury in a retort, there remains in the latter a dark-coloured substance, which was found by Professor Johnston to be similar in composition to cyanogen, that is, composed of 2 equivalents of carbon 12, and 1 equivalent of nitrogen 14=26. It appears therefore that it is a bicarburet of nitrogen, isomeric with cyanogen, but differing from it essentially in its physical and chemical properties, the paracyanogen being solid whilst cyanogen is gaseous. This compound is also formed when mercury is kept in an alcoholic solution of cyanogen.

PARADE is an assemblage of troops for muster, exercise, inspection, &c. The word also signifies the ground on which the exercise and drill are performed.

PARADISE (παράδεισος) is a word of Persian origin, signifying a kind of park or pleasure-ground inclosed with walls, and well watered and planted, and stocked with animals for the chase. (Pollux, ix. 13; Gellius, ii. 19.) It was adopted into the Greek language, and applied to any pleasant place. The Septuagint translators use this word for גַּן־עֵדֶן the *garden of Eden*, where God placed the first man upon his creation. (Gen. ii. 8; iii. 23.) Respecting the situation of this place, we are told, in Gen. ii. 8–14, that it lay eastward in the land of Eden, and that it was watered by a river, which, after passing through the garden, divided into four streams, of which the first, Pison, compassed the land of Havilah, where there was gold, bdellium (either the pearl or a sort of gum resin), and the onyx stone; the second, Gihon, compassed the land of Cush; the third was Hiddekel (the Tigris), which went towards the east of Assyria; the fourth was the Euphrates. Many attempts have been made to fix the position, but nothing satisfactory has been, or can be, ascertained, as it is clear the face of the earth, and probably the course of the streams, must have undergone great changes since the period of its existence.

PARADOS is a traverse placed in fortifications in the rear of a work, to cover it from reverse fire.

PAR'ADOX (from παράδοξος, "contrary to received opinion") is a term applied to a proposition which is opposed to the general belief, or to one which appears at first sight to contradict some previously ascertained truth. The nature of a paradox and the distinction between it and a contradiction is clearly explained in the following sentence from Bishop Horsley's 19th Sermon :—" When two distinct propositions are separately proved, each by its proper evidence, it is not a reason for denying either, that the human mind, upon the first hasty view, imagines a repugnance, and may perhaps find a difficulty in connecting them, even after the distinct proof of each is clearly perceived and understood. There is a wide difference between a paradox and a contradiction. Both, indeed, consist of two distinct propositions, and so far only are they alike; for of the two parts of a contradiction, the one or the other must necessarily be false: of a paradox, both are often true, and yet, when proved to be true, may continue paradoxical. This is the necessary consequence of our partial view of things. An intellect to which nothing should be paradoxical would be infinite. . . . . In all these cases there is generally in the nature of things a limit to each of the two contrasted propositions, beyond which neither can be extended without implying the falsehood of the other, and changing the paradox into a contradiction; and the whole difficulty of perceiving the connection and agreement between such propositions arises from this circumstance, that by some inattention of the mind these limits are overlooked."

This word was also used by the Greeks for a remarkable saying. Cicero, in his work entitled 'Paradoxa,' illustrates six of these paradoxes, borrowed from the Greek stoics. These propositions are the following :—1. The honourable is the only good. 2. Virtue is sufficient for happiness. 3. All sins and right actions are equal. 4. Every fool is mad. 5. The wise man alone is free, and every fool is a slave. 6. The wise man alone is rich.

PARAFFIN ($C_{40}H_{42}$?). A white crystalline body first found by Reichenbach in coal, wood, and animal tars. He found that the lower the temperature at which the tar was produced the larger the amount of paraffin formed. It is now obtained in large quantities by distilling cannel coal at the lowest temperature practicable, the rectified and purified product constitutes the basis of *paraffin oil.* The tar is filled with crystals of paraffin, which may be collected upon a strainer, and purified by pressure and treatment with concentrated sulphuric acid and caustic soda alternately.

Paraffin is a beautifully white translucent body, like spermaceti, and when manufactured into candles gives a clear smokeless light. It fuses at 110° Fahr., and is remarkable for its resistance to chemical action; hence its name from *parum affinis.*

PARAFFIN, is one of the numerous substances which chemical discovery has added to the list of liquid fuels for lamps; its nature may in some degree be shown by the proceedings in a chancery suit which took place in 1854. In 1850, Mr. Young had taken out a patent for "the treatment of certain bituminous mineral substances, and in obtaining products therefrom." It was Paraffin oil, obtained from bituminous coal. The coal was distilled at a low red heat. If a higher temperature were employed, the elements would be converted into gas and naphthaline; but the lowness of the heat prevented this, and brought over the product as an oil rich in paraffin; and this oil, when purified, became useful as a fuel and a lubricator. On the other side, it appeared that the Hydro Carbon Gas Company of Manchester were the owners of two patents, obtained by Mr. White, for inventions relating to the gas manufacture. One was for obtaining a compound gas from the vapours of oil, fat, and tar, combined with hydrogen obtained by the decomposition of water; while the other was for using resin, tar, fat, or pit coal for the same purpose, but at a white red heat. The defendants sold an oil which they called Paraffin oil, and which the plaintiff claimed as belonging to his patent. The defendant pleaded that paraffin is not a new substance, it having been produced many years ago by Reichenbach, who showed that it can be obtained from wood-tar and coal-tar. The decision was in favour of the plaintiff, as having adopted a low temperature for obtaining paraffin, on finding that a greater heat would result in the production of naphthalin.

PARAFFIN OIL. [PARAFFIN.]

PARALLACTIC ANGLE. The angle which measures the parallax of a celestial body. [PARALLAX.]

PARALLACTIC INSTRUMENT, or *Ptolemy's Rules,* the name given to an instrument invented by Ptolemy for determining the moon's parallax, and described by him, 'Almagest,' b. v., c. 12.

A B, B C, *fig.* 1, are two stout wooden rods turning on a pin or centre at B; B A = B C; A C is a third divided rod, also turning on a pin at A, and passing through a loop or bifurcation of the rod B C at C; P Q, a plumb-line by which A B is adjusted vertically; E F, two sights fixed on C B. It is evident, if A B be truly perpendicular, and any object be seen in the direction E F, that A C will be the chord of the angle A B C, that is, of the zenith distance of the object. A C may be divided as a scale of equal parts, and the angle deduced from a table of chords, or as a line of chords to radius A B, in which case the angle may be read off at once.*

A figure of a similar instrument may be found in Tycho Brahe, 'Astron. Instaur. Mechanica,' sheet C. We have thought *Ptolemy's*

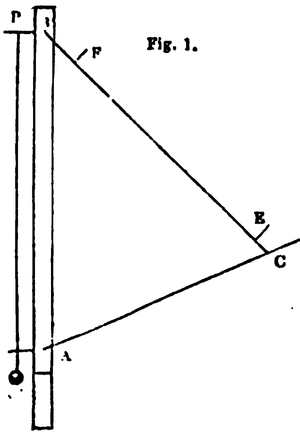


Fig. 1.

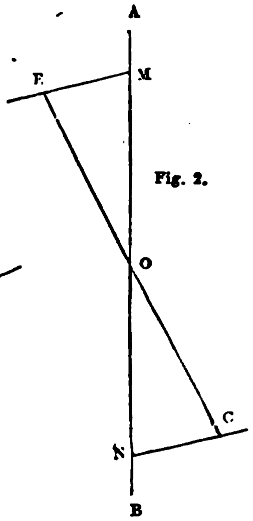
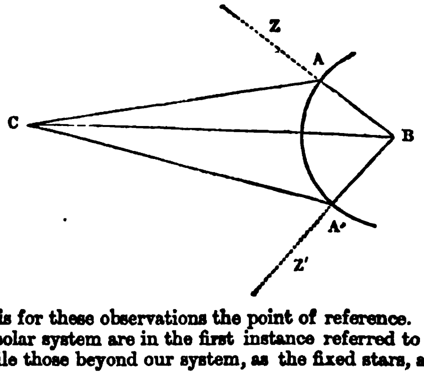


Fig. 2.

Rules worth notice chiefly as pointing out a very cheap and accurate instrument for obtaining the time by the method of equal altitudes. Let A B be a rod turning on pivots above and below,—for instance, between the sill and architrave of a window,—and capable of being set perpendicular by a plumb-line, supposed in the figure to hang behind A B. E C, a stout edge-bar turning round a pin at O, and fixable in any direction by two laths, E M, C N. On E C a telescope is lashed (one sufficient for the purpose might easily be made of a tin tube and spectacle-glasses), with one or more horizontal wires placed in the focus. If the times of contact of the sun's limbs with the horizontal wires be observed in the forenoon and again in the afternoon (the axis A B being in both cases truly adjusted, and the instrument in other respects unchanged), the data will be obtained for finding the time shown by the watch when the sun is on the meridian—that is, *apparent noon*—with great accuracy and very little calculation. (See Schumacher's 'Hülfstafeln,' p. 49, &c.; Baily's 'Tables,' pp. 92, 148, and many other collections.) The determination of the error of the watch by equal altitudes of the same star is even more simple, as there is then no motion in declination to be allowed for, and the middle time by the watch of similar observations is the time when the star passes the meridian, or its right ascension, which is known from the 'Nautical Almanac,' or from well-known catalogues. The observer must be very careful to adjust the instrument by the plumb-line to the same position in both observations, and he must have a watch which will keep time correctly for the interval.

Sometimes the word *parallactique* is used to signify the instrument known to us by the name of EQUATORIAL. Lalande ('Astronomie,' § 2278) says the proper word is *parallatique,* or that which follows the *parallel* of stars; he reserves *parallactique* for *Ptolemy's Rules.*

PARALLAX (παράλλαξις), used in astronomy generally for the angular variation in the position of an object caused by the excentric situation of the observer with respect to a certain point of reference. Thus the parallax of the moon, sun, planets, comets, is the difference between the position of any of those bodies as seen from the surface of the earth and that in which they would be seen if the observer were placed at the earth's centre. The parallax of the fixed stars is the difference between their places as seen from the earth and from the



sun, which is for these observations the point of reference. All bodies within the solar system are in the first instance referred to the earth's centre; while those beyond our system, as the fixed stars, are referred to the centre of the sun, and the change arising from excentric position in each case is called parallax.

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* Some liberties have been taken with Ptolemy's description, and several omissions made. He seems to have been singularly unlucky as an observer, for at 50° 55′ Appar. Zen. Dist. he found the moon's parallax = 1° 7′, whence the horizontal parallax is 1° 26′, and the distance of moon from the earth 39·8 of the earth's radii. He has drawn the latter conclusion, but fortunately seems not to have used it in his theory.

From the effects of parallax we derive all our knowledge of the distance and magnitude of the bodies which are visible in the heavens.

Let A B be any line the length of which is accurately measured, and let the angles C A B, C B A, be observed, then the distances C A and C B can be computed. In this way trigonometrical surveys are made, with the further precaution that the angle A C B is observed when this is possible, and C is to be fixed with great nicety. The angle A C B is known, since it $= 180° - (\text{BAC} + \text{ABC})$, and we have A B : B C : : sin A C B : sin C A B. In the above figure, let A be the position of a spectator on the earth's surface, B the centre of the earth, C the moon, and Z (in B A produced) the geocentric zenith. Then Z A C is the apparent geocentric zenith distance at A; Z B C the true geocentric zenith distance, that is, that which would be seen from the centre of the earth; and $\text{ACB} = \text{ZAC} - \text{ZBC}$, the moon's parallax: also

$$\sin \text{parallax} = \frac{\text{AB}}{\text{BC}} \times \sin \text{Appt. geocent. zen. dist.}$$

When A C is at right angles to B A, this sine = 1, and the moon is in the horizon. This value of the parallax is called the *horizontal* parallax; naming this P, and any other value of the parallax p, we have

$$\sin \text{P} = \frac{\text{AB}}{\text{BC}}, \text{ and}$$

$$\sin p = \sin \text{P} \times \sin \text{appt. geocent. zen. dist.}$$

It is evident that if P can be measured, the distance R of the moon's centre from the centre of the earth can be found, for the other quantity A B or r is the radius of the earth at the place of observation, which is known from terrestrial measurement. Now, suppose a second spectator on the same meridian at A′, whose geocentric zenith is Z′, and that the two observers each observe the moon upon the meridian at the same moment: then, if z and z' be two observed geocentric zenith distances, and p and p' the parallaxes, $\text{P} = \frac{\text{BA}}{\text{BC}} = \frac{r}{\text{R}}$, $\text{P}' = \frac{\text{BA}'}{\text{BC}} = \frac{r'}{\text{R}}$, and

$$\angle \text{ABC} = z - p$$

$$\angle \text{A}'\text{BC} = z' - p',$$

and adding $\text{ABA}' = z + z' - (p + p')$, where A B A′ is the sum or difference of the geocentric latitudes of A and A′, and z and z', are known by observation; hence the value of $p + p'$, or A C A is found. From the equations

$$p + p' = z + z' - \text{ABA}'; \ \sin p = \frac{r}{\text{R}} \sin z; \ \sin p' = \frac{r'}{\text{R}} \sin z';$$

it is easy to find the value of R.

In practice, though the process is less simple, the principle remains the same. Two distant observatories can scarcely be found exactly on the same meridian; but the tables of the moon enable us to reduce the observation at one of the observatories to exactly *what it would have been* if it had been made under the meridian of the other. When the parallax is small, it is advisable to compare the planet by the *micrometer* with stars which are nearly in its parallel. When the parallax, and consequently the distance, for any given time is known, the distance and parallax for any other time can be found from theory. By observations of this kind, combining the observations of La Caille at the Cape of Good Hope with other observations made in Europe, the parallax of the moon and of Mars were fixed with great accuracy. The late Professor Henderson investigated the value of the moon's parallax from a comparison of his own observations at the Cape with those made at Greenwich and Cambridge. ('Mem. Ast. Soc.,' vol. x., p. 283.)

It will be seen that the point from which the moon's zenith distances are to be measured is in the prolongation of a line drawn from the centre of the earth, and not in the prolongation of a line in the direction of gravity, which is pointed out by a plumb-line. The correction which is to be applied to the astronomical zenith, in order to find out the geocentric zenith, is given in many collections of tables for a certain hypothesis of the figure of the earth. The horizontal parallax given in the 'Nautical Almanac' is that which belongs to the equator where the earth's radius is largest. A second table for reducing this equatorial horizontal parallax to the parallax proper to the place of observation (namely, log. rad., supposing the equatorial rad. =1) always accompanies that above referred to.

Parallax of the Sun.—The first attempt to determine the sun's distance seems to be due to Aristarchus of Samos, and presupposes the knowledge of the moon's parallax. On drawing a figure, it will immediately be seen that when the moon has completed her first quarter (she is then said to be *dichotomized*, or cut exactly in two), the sun, moon, and spectator form a triangle, which is right-angled at the moon. Now the angle which separates the sun from the moon can be observed at the same instant: suppose it = E, we have

Distance earth & sun = distance earth & moon × sec. E.

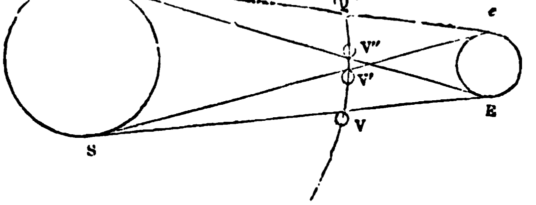
The exact moment of *dichotomy* cannot be noted with much accuracy; yet repeated observations would show that the sun was far more distant than the moon. The ancient astronomers seem to have estimated the sun's parallax to be from 2′ to 3′, which suffered a gradual reduction as the means of observation improved. The parallax of the sun might with modern instruments be measured in the same way as that of the moon or planets above described, but not so well, as a longer time must elapse between the passage of the sun and that of a star nearly in the same parallel. Ptolemy says that Hipparchus computed the moon's parallax from the phenomena of solar eclipses; that is, he deduced the value of the moon's parallax from the phenomena of solar eclipses on two suppositions of the sun's parallax: namely, that it was = 0; and, again, that it was a definite small quantity. As the circumstances of a solar eclipse vary from the effects of parallax, it is clear that in this way Hipparchus would get something like equations of condition involving the parallaxes of the sun and of the moon, which could be solved as soon as, by the problem of Aristarchus or by any other method, he could determine the relation between these two quantities.

We have thus shown that an approximate knowledge of the distances of the moon, sun, and planets, in terms of the magnitude of the earth, requires nothing more than observation and the solution of a triangle one side of which and the two including angles are known. The magnitudes of these bodies can be immediately calculated from their apparent diameters and true distance; so that up to this point there is no room for scepticism, if it be granted that the angles of a triangle equal two right angles.

There is a method of ascertaining the parallax by one observer. Let Mars in opposition be the object, and compare it in right ascension with a neighbouring star in the same parallel on the meridian, and also several hours before and again after his transit. The parallax, being wholly in a vertical circle, will not affect the right ascension in the meridian: hence the meridian comparison will give the true difference of right ascension between the planet and star. The other observations (after correcting the place of Mars by his hourly motion, which is known either from the tables or from observations on preceding and succeeding days) present right ascensions of the planet affected by parallax in different ways, and from these effects it is easy to compute the actual value of the horizontal parallax, and consequently the distance of the planet in terms of the earth's radius at the place. This method has recently been proposed by the Astronomer-Royal, as well adapted for determining the parallax of the star from observations made during the oppositions of 1862 and 1864.

Kepler's discoveries *—that the planets move in ellipses round the sun in the focus; that the area swept by each radius vector in a given time is a constant quantity for the same planet; and lastly, that the squares of the periodic times are as the cubes of the mean distance—have supplied means for a much more accurate determination of the sun's parallax. Assuming these laws, the *forms* of the orbits of the earth and planets, and their *relative* distances, can be determined from observation: hence, if the parallax of any one planet can be found, the parallaxes of the sun and of all the other planets can be computed. Observations of Mars, for instance, at his opposition, made at the Cape of Good Hope and at Greenwich, will afford a very tolerable value of his parallax, and hence of his distance. Again, as the proportion between the distances of Mars and the earth from the sun at any time is known from the form of their orbits and their periodic times, and the angle between the sun and Mars at the earth can be observed, the triangle between the sun, earth, and Mars can be completely solved, and hence the distance of the sun and his parallax be computed. These observations can be repeated at every opposition of Mars; and if Mars be compared by the micrometer with stars near the same parallel, there is scarcely a limit to the possible accuracy of the observations.

The observation however by which the parallax of the sun is determined with the greatest certainty, is that of the passage of Venus over the sun's disc, commonly called the *transit* of Venus. [TRANSIT OF VENUS.]



In the figure let S s be the sun, E e the earth, and V and V′ two positions of Venus, which is supposed to be moving in the direction V V′. To make the figure simple, we suppose the earth to be at rest, and that V V′ represents the excess of the angular motion of Venus above that of the earth. A spectator at E will see the commencement of the transit when Venus is at V, but a spectator at e will only begin to see it when Venus is at V′. The time which must elapse between these two moments is equal to the time in which Venus passes from V to V′, or in which she describes the angle ES*e* round the sun with her *relative* angular motion. But the angle ES*e* is twice the sun's horizontal parallax; hence, since the time elapsed between the ingress at the two places is known from observation and from the difference of longitudes, and the hourly angular motions of Venus and the earth round the sun are known from the tables, and consequently the difference of these motions, the horizontal parallax of the sun can be found. It is evident that as the ingress is accelerated at E and retarded at *e*, so the egress will be accelerated at E and retarded at *e*, Venus then occupying the positions V″, V‴.

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* Though these discoveries are due to Kepler, the satisfactory proof of their truth was given by Newton.

Let us suppose further that a spectator who saw the ingress at E, and therefore as early as possible, should by the rotation of the earth be carried to *e*, where he would see the egress as late as possible, while the spectator of the late ingress at *e* is in like manner carried to E, where he sees the earliest egress.* In the first case the time of the transit is increased as much as possible by the effect of parallax, and in the latter case it is equally diminished. Now suppose the parallax of the sun to have a certain value, the parallax of Venus and the effect of these parallaxes in increasing or diminishing the duration of the transit for any specified places of observation can be computed. Hence when the durations are really observed, the differences between the observed duration and that which would have been observed if the spectator had been placed at the centre of the earth will fix the actual amount of the parallax. The especial excellence of this method consists in the nicety† with which a particular phenomenon can be observed, namely, the first streak of light which is seen after the interior contact at ingress and the last streak before the interior contact at egress. Two points on the earth are chosen where the beginning and end are both visible, in one of which the duration is shortened as much as possible, while it is increased in the other. Every observation of either ingress or egress can in fact be used for determining the parallax, provided the longitude of the place of observation and the time be sufficiently well known; but where both the ingress and egress are observed, the duration alone requires care. Transits of Venus were observed in 1761 and 1769, and the parallax of the sun deduced by various geometers. (Lagrange, 'Mémoires de Berlin,' 1766; Encke, 'Der Venus Durchgang,' Gotha, 1824.) The next transits will take place in 1874 and 1882.

In the preceding part of this article the methods of determining the parallaxes, and consequently the distances of the bodies composing our system, have been described, and we will now point out the way in which this knowledge is applied. Every observation of the sun, moon, or planets is affected by parallax and must be corrected for this previous to further calculation. All celestial bodies are apparently elevated by the refraction of the atmosphere, and those of our system are depressed by the effect of parallax. In nautical works there are tables for reducing the observed altitude of any heavenly body to its true altitude, namely, to that which it would have if there were no atmosphere and the spectator were at the earth's centre. In most of the problems from which the longitude is determined astronomically, in solar eclipses, occultations, and lunar distances the great difficulty and trouble is in computing the effect produced by the moon's parallax. Astronomers have invented convenient formulæ for this purpose, according to the planes to which the bodies are referred. Thus in working out an occultation, the moon may be referred to the plane of the *horizon*, when the effects of parallax in altitude, and, if great accuracy be required, in azimuth, must be computed; or again, to the *equinoctial*, when the parallax in right ascension and declination is to be calculated; or finally, to the *ecliptic*, when the parallaxes in longitude and latitude must be found. The rules for these computations are given in treatises on Astronomy.

The mean equatorial horizontal parallax of the sun, according to Encke, = 8·5776″. Its true value for every ten days is given in the 'Naut. Alman.' at the end of the ephemeris of the sun and moon. The equatorial horizontal parallax of the moon for mean noon and midnight is at page III. of each month, and the parallaxes of the planets are in the last column of the planetary meridian ephemeris.

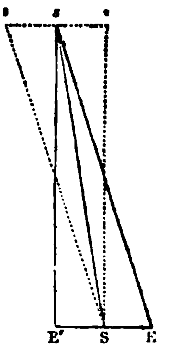
One effect of parallax is, that the moon appears under a larger angle when near the zenith than when near the horizon. This is contrary to common opinion, but may be very easily proved experimentally, by any one who can handle a sextant with ordinary care. When the moon is in the zenith, the horizontal diameter may be *augmented* from 30″ to 40″. There is a table for this augmentation of the moon's semidiameter in most nautical works.

Constant of Parallax (*la constante de la parallaxe*) is the angle under which the earth's radius would be seen at the centre of the moon when she is at her mean distance. The radius chosen by La Place is that which belongs to a latitude of which the square of the sine = $\frac{1}{3}$.

PARALLAX, ANNUAL, is the angle under which the earth's orbit is seen by a superior planet.

PARALLAX OF THE FIXED STARS. When Copernicus proposed his hypothesis of the earth's motion, one striking *astronomical* objection was, that the enormous displacement of the spectator's place which his system supposed was not supported by a corresponding change in the positions of the fixed stars. Every improvement in instruments, in the art of observing, or in the science of computation, seemed to increase the distance of the sun, and consequently the orbit of the earth, and still no sidereal change could be detected. Hence, until the discoveries of Newton brought forward physical arguments, of which, however, the conclusiveness is not immediately visible, the Copernican hypothesis was embraced on the grounds of its symmetry and simplicity rather than on demonstration. Opponents might always ask for the *experimentum crucis*, the effects of the earth's motion in the apparent displacement of the fixed stars, and this could not be supplied.

Many attempts were, however, made. Hooke erected a zenith sector at his chambers in Gresham College, and made some incomplete observations in which he fancied he could trace the effects of parallax. Flamsteed found variations in the north polar distances of fixed stars, which he attributed to parallax, although, as was shown by Cassini and Roemer, this would have produced results with a totally different law. Roemer himself, after many efforts to deduce parallax from observations in declination, renounced the attempt, on account, as he says, of "a certain variation in the declinations of stars which can neither be attributed to refractions nor parallaxes," and pursued his investigation by observations in right ascension, in which it seems he believed himself to be successful. At length Bradley commenced the research with far better astronomical means, and by his discoveries of aberration and nutation, fully explained the phenomena which had perplexed his predecessors. It is curious that Roemer, who had discovered the gradual transmission and finite velocity of light, should have been perplexed with the necessary results of this very property in another shape; and that Bradley, while pursuing the problem of parallax, which had been originally interesting as a proof of the earth's *change of place*, should have hit upon phenomena which satisfactorily proved the earth's *motion*, and so confirmed the Copernican hypothesis by evidence different from what he sought. Bradley's observations further showed that the effect of parallax in any of the stars observed by him could not amount to 2″ and probably was not 1″.



The nature of the changes in the places in the fixed stars, which the change of position in the earth would produce, may be seen from the following figure. Let S be the place of the sun, E that of the earth, and *s* that of a fixed star. Then the star is seen from the earth in the direction E *s*, and from the sun in the direction S *s*; the difference in these two directions is the angle E *s* S, that is, the angle of parallax. If S *s*′, *s s*′, be drawn parallel to E *s*, E S, and the observations made from the earth be referred, as observations of this kind are always supposed to be, to the sun, the true place of the star is at *s*, while the place which is assigned to it by observation is *s*′. At the end of half a year the place of the earth will be at E′, and the star is seen in the direction E′ *s*. Hence it is referred to the position *s*″ in respect of S. It is evident that the effect of parallax is to cause the star to appear to describe an orbit round its true place in a plane parallel to the ecliptic, similar and equal to the earth's orbit round the sun; and further, that parallax is always in a plane passing through the star, sun, and earth, and that its effect is to diminish the angle which the sun and star subtend at the earth. When this is clearly conceived, it will also be seen that this ellipse, which is similar to the earth's orbit, will be seen obliquely from the earth, and consequently be projected into another ellipse with altered proportions. The same figure would serve for an explanation of aberration, except that aberration is in a plane defined by the star and the *direction* of the earth's motion, which direction is at right angles to the line joining the earth and sun, so that the *phenomena* of parallax and aberration are similar, only the effect of parallax is at right angles to the effect of aberration. This affords a convenient mode of computing the coefficient of parallax when that of aberration is known.*

There is another view of parallax. Suppose a spectator at the star *s*; then he would see the earth's radius vector S E under the angle of parallax. The earth's orbit may be considered to be circular, and as the plane is inclined to a spectator anywhere except in the pole of the ecliptic, the earth will appear to describe an ellipse about S as centre. The nearer the star *s* is to the ecliptic, the more excentric this ellipse will be,[*] but in all cases there is a diameter of the earth's orbit, namely, that which is perpendicular to the line joining S *s*, which is seen in its true proportions without foreshortening.

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* The explanation is only intended to exhibit the *principle* on which this very important problem depends.

† This observation seems not to have been quite as definite as was expected; a little confusion was remarked at the point of interior contact before the formation of the thread of light, a sort of black drop (gutta nigra). Mr. Baily saw several black threads connecting the edges of the sun and moon during the formation and breaking up of the annulus in the eclipse of May 15, 1836 ('Mem. Ast. Soc.,' vol. x. p. 1), which seems to be a phenomenon of the same kind.

* This similarity between aberration and parallax is not rigorous, but nearly so. It would be strictly true if the earth moved uniformly in a circle. There are convenient tables for computing aberration for a given constant of aberration. Calculate the aberration by these tables for ☉ + 90°, ☉ being the sun's longitude at the time, divide by the seconds of the constant of aberration, and you have the coefficient of parallax, the parallax being supposed = 1″. Also the times when the parallax in right ascension or declination is the greatest possible will be when the effect of aberration in those directions is 0, and *vice versâ*.

Since Roemer and Bradley, many astronomers have sought for parallax by observation in right ascension and declination. Bessel could find no evidence of such an effect in Bradley's transit or zenith distance observations. Piazzi, from meridian zenith observations, concluded that Sirius had a parallax of 4" and Procyon one of 5"·7; Calandrelli found a parallax of 4"·4 in *α* Lyræ. But the most persevering and accurate observations for deducing the value of parallax from meridian observations were prosecuted by Dr. Brinkley at Dublin with an 8-foot circle by Ramsden, and by Pond at Greenwich with the 6-foot mural-circle of Troughton. Dr. Brinkley conceived that he had established without doubt a sensible parallax in *α* Lyræ, *α* Cygni, and *α* Aquilæ, while Pond maintained that no sensible parallax was shown in any of those stars, from observations in declination and in right ascension. He further corroborated this result by comparing two stars, *α* Cygni and *β* Aurigæ, which have nearly the same declination and opposite right ascension, with a fixed tube. This controversy continued for several years, and though there can be no doubt *now* that Dr. Brinkley was mistaken, and that Pond was right in his conclusions, there is a good deal of interest attached to the discussion. Dr. Brinkley's last memoir is in the 'Transactions of the Royal Irish Academy,' vol. xiv. Mr. Pond's paper on the parallax of *α* Lyræ will be found in the 'Phil. Trans.,' 1823, part i., p. 53.

Sir William Herschel first pointed out the mode of detecting parallax which affords a probability of success, namely, that which depends upon the measurement of double stars. In his paper, 'Phil. Trans.,' 1782, part i. p. 82, he showed that if the stars which compose a double star be at different distances from the earth, which was at that time supposed to be the chief cause of differences in magnitude, they must be differently affected by parallax, and therefore that their apparent distance from each other will be altered by a change of position in the spectator. Now as the apparent distance of two neighbouring stars can be measured with great accuracy,[†] the problem of parallax is thus reduced to that of finding a double star in which a variation of distance is observable, and following the law which the earth's change of place requires. It was in this inquiry that Sir William Herschel discovered that very many double stars have a relative motion both in distance and angular position, which proves them to be a connected system, and that unexpected result, which he prosecuted with all his ardour and genius, seems to have led him from the investigation of parallax into his profound and original researches. Sir John Herschel ('Phil. Trans.,' 1826, part iii., p. 266,) extended his father's proposal for the discovery of parallax by showing that the variation produced by parallax in the angle of position of two stars is a more sensible phenomenon and one more easily measured than the variation in distance; and in the 'Phil. Trans.,' 1827, p. 126, he published a considerable list of stars suitable for his research, with the times of year when the observations would show the greatest effect of parallax.

It has been shown that the earth's change of place in its orbit causes each star to have an apparent motion in an ellipse of which the major axis is parallel to the ecliptic and equal to the diameter of the earth's orbit as seen at the distance of the star, and the minor axis equal to the major × sine *'s latitude. If then the stars be a connected system, and comparatively near each other, the stars will appear to describe two equal and similar elllipses, and the line joining their apparent places will be equal and parallel to the line joining their true positions. It is therefore in vain to look for any effect of parallax in micrometrical or relative measures of distance and position in a connected system. But if one of the stars be much farther from us than the other, suppose it ten times farther off, then the apparent ellipses will continue to be similar, and similarly described, only the dimensions of that described by the more distant star will be 1-10th of that described by the nearer star, which comes to the same thing as supposing the more distant star to be fixed, and the nearer star to describe round its true place an ellipse of 9-10ths the actual dimensions. If with Sir William Herschel we measure the apparent *distances* of the two stars, those are best suited to the purpose in which the line joining the stars is in the direction of the major axis of the parallactic ellipse, that is, is parallel to the ecliptic. If we proceed by measures of position, as recommended by Sir John Herschel, those stars are most favourable in which the line joining the two stars is perpendicular to the ecliptic. It is scarcely necessary to say that these conditions are not rigorous, and that stars tolerably near the pole of the ecliptic are equally well suited to either kind of measure, as the apparent ellipse is then almost a circle. Since the application of clock-work to large equatorials, we think that the measures of the distance of double stars may be made nearly as accurately, and even more easily, than angles of position; and further, that any telescopes which have yet been constructed may be mounted equatorially and carried by clock-work. Most of the close double stars are probably connected, and are therefore unfit for the detection of parallax.

In the last-named property, that of measuring considerable angles, the heliometer is unrivalled, and thus we see its especial use in the researches connected with parallax. It is almost hopeless to attack the problem by any other means at present known; and the divided eye-piece, which is found very useful for *small* measures of distance, is, like the wire micrometer, *limited* to this object.

For his researches on parallax, Bessel selected the double star 61 Cygni, which is a double star having a large proper motion. This property leads us naturally to guess that it is a comparatively near star, as its actual velocity would otherwise be enormously large. Two stars *a* and *b* were chosen, *b* in the direction joining the component stars of 61 Cygni, and *a* at right angles to this direction. The observations of *b* are made by bringing it into the middle of the two stars, those of *a* by placing it in the same line with the two stars. As the two stars of 61 Cygni are nearly of the same brightness, the observation is exceedingly accurate. These measurements were continued for fourteen months with very little interruption. The stars *a* and *b* are so far removed from 61 Cygni as to render any connection highly improbable. Variations were found in these distances, which, being compared with the effect which parallax would produce, are *exactly* accounted for; therefore this variation is produced by parallax, for it can be shown that any other *known* cause of disturbance has been got rid of by the skill of the observer. The result is that the parallax of 61 Cygni is 0"·314; whence the distance of 61 Cygni is 658,000 times the distance of the earth from the sun, and light from the star is 10¼ years in reaching us.

This result has received a most satisfactory confirmation from the researches of Professor Peters, and those of the late Mr. Johnson, director of the Radcliffe Observatory, Oxford. The value deduced by the former of these astronomers, namely, 0"·349, was founded on observations made by himself with a vertical circle at the Imperial Observatory of Pulkowa. In 1852-3 Mr. Johnson measured the distance of the star from two other small stars in its vicinity with the Oxford heliometer, and obtained 0"·384 for the value of its parallax.

The parallax of *α* Lyræ, was determined by M. Struve, in the year 1835. The method employed by him consisted in measuring with a wire micrometer the distance of the star from another bright star in its vicinity. In this way he found the parallax of *α* Lyræ to be 0"·261. The parallax of this star has also been investigated by Professor Peters, M. Otto Struve, and Mr. Johnson. M. Otto Struve, by combining his own value of the parallax of the star with the values obtained by his father and Professor Peters, obtained 0"·1549 for the definitive result. Mr. Johnson obtained very imperfect evidence in favour of a sensible parallax of the star.

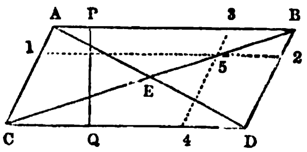
The late Professor Henderson, of Edinburgh, determined the parallax of the bright star *α* Centauri, from observations made by himself with the mural circle at the Cape of Good Hope in the years 1832-3. In this case, the resulting parallax was large, amounting to 1"·16. Mr. Maclear, from observations made at the Cape in the years 1839-40, found the parallax of the same star to be 0"·9128; and from subsequent observations extending down to 1848, he deduced 0"·9187 as the most probable value of the parallax. The parallaxes of several other stars have been investigated in recent times, but no trustworthy results have yet been arrived at.

PARALLAX, in practical optics, is the longitudinal misplacement of the wires in a telescope or microscope. If the wires are not at a proper distance from the object-glass, the image of the object is not seen distinctly when the wires are so seen. On giving a little motion to the eye, the object will seem to move upon the wires. If it move in the direction of the eye, the cell carrying the wires must be pushed in, and *vice versâ*. There are means for this adjustment in all instruments which require it, and it is a point to which the attention of observers should be very carefully directed.

PARALLEL. [PARALLELS.]

PARALLEL PRESSURES. [PRESSURE.]

PARALLELOGRAM (*παραλληλό-γραμμα*, parallel-drawn figure) is the mathematical term for a four-sided figure of which the opposite sides are parallel. Such a figure may be obtained from *any* four-sided figure by bisecting the four sides and joining the adjacent bisecting points. When all the angles of a parallelogram are equal, they are therefore right angles, and the figure is called a RECTANGLE. When the sides are also equal, the figure is a SQUARE: matters of more historical interest are connected with either of these terms than with the generic term parallelogram. Referring therefore to those articles, we shall here give the principal properties of parallelograms in general.



1. The opposite sides are equal, as AC and BD.
2. The opposite angles are equal, as ACD and ABD, and adjacent

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[*] The semi-axis major is the earth's radius vector, and the semi-axis minor is the earth's radius vector × sin of *'s latitude.

[†] It is perhaps more easy to determine the distance of a double star to 0"1 than to fix an absolute place to 1"0.

angles (as those at A and B) are together equal to two right angles, or are *supplements* of each other.

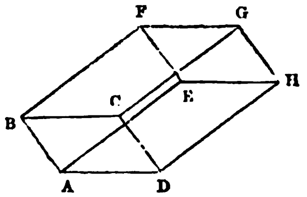
3. The diagonals (A D and B C) bisect one another.

4. The sum of the squares on the four sides is equal to the sum of the squares on the diagonals.

5. The area of a parallelogram depends only on the side (as C D) and the perpendicular distance (P Q) between that and the opposite side; so that parallelograms on equal bases and between the same parallels are equal.

6. If the point (5) be taken on a diagonal (C B) and made the vertex of a pair of parallelograms (A 153 and D 452) lying in the equal triangular halves of the parallelogram, these parallelograms will be equal to one another in area.

PARALLELOPIPED (παραλληλ-επίπεδον, parallel-plane solid) more correctly written *parallelepiped*, is the name given to a solid contained by six parallelograms, which are equal and parallel, two and two. It is in fact a quadrangular prism.



When all the parallelograms are rectangles, we have one of the figures to which our eyes are most accustomed, as in the case of a die, a box, a plank, a room, &c. &c. Persons not acquainted with mathematics would hardly believe that English mathematicians seldom express this most simple and elementary of all solids in less than ten syllables, as follows :—

rect-an-gul-ar par-all-el-o-pi-ped.

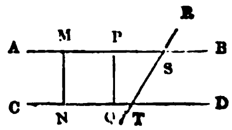
A more simple term might easily be obtained, and one perfectly consistent with analogy, namely *right solid*. Thus a right line might be conceived as generated by the most simple motion of a point; a right surface (or rectangle) by the most simple motion of a right line; and a right solid (or rectangular parallelopiped) by the most simple motion of a right surface. We shall consider the properties of a right solid in the article Rectangle.

When the adjacent rectangles of a right solid are squares, the solid is a Cube, for which fortunately there is a shorter term than equilateral rectangular parallelopiped.

The number of cubic units in a parallelopiped is found by multiplying the number of square units in either base by the number of linear units in the perpendicular distance between that base and the opposite one. The diagonals A G, B H, C E, D F, meet in the same point, which bisects them all, and the sum of their squares is equal to the sum of the squares of all the twelve sides of the solid.

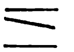
PARALLELS (παράλληλα, by the side of each other), the name given by the Greek geometers to lines in the same plane having that relation of situation of which it is one of the most obvious properties that such lines never meet, however far they may be produced or lengthened.

If we examine the properties of lines experimentally, it will be easy to satisfy ourselves of the existence of such pairs as A B, C D, which neither diverge nor converge, and to which common perpendiculars, such as M N and P Q, all of the same length, can be drawn through any point of either. Moreover the angles R S B and R T D made by the same line with both, will be found to be the same. If then we take the notion of permanence of direction, which always accompanies that of straightness [Direction], and also the notion of differing directions, which is suggested by two lines which make an angle, we may readily see that the relation of situation which, adopting Euclid's term, may be called *parallelism*, is really that which would be also conveyed by the words sameness of direction; so that if two lines A and B be parallel, A may be substituted for B or B for A, in any proposition which involves relations of direction only, without affecting the truth of that proposition, if true, or its falsehood, if false.



Geometry, as every beginner knows, depends upon a small number of self-evident truths, or rather of propositions the truth of which (*with one exception*) is so soon and so easily perceived, that no one doubts of them when stated with ordinary attention to clearness of expression. The exception alluded to appears for the first time in Euclid, and has been the occasion of a controversy which has lasted from his time to the present.

It will be remarked that the definition of parallel lines is purely negative: it describes what they are not, not what they are: if lines which meet, or which will meet if produced, be called intersectors, parallels are *non*-intersectors. Those who would found geometry upon definitions entirely, may think that the difficulty of the theory of parallels arises from insufficient definition: but those who believe it to be deducible from real and positive conceptions, having nothing arbitary about them, must suspect that, in this purely negative definition of parallels, we have not sufficiently described that very obvious relation of position which distinguishes parallelism from convergence, however short the lines we image to ourselves, or however little we think of what will take place if they are produced. Euclid, proceeding upon axioms the admission of which is not considered to be a question connected with the present difficulty, establishes the following proposition :—If the two lines S B and T D make the angles P S T and S T D equal, or R S B and S T D equal, or B S T and S T D together equal to two right angles (all which amount to the same thing), then S B and T D are non-intersectors. But before any further step can be made, it must either be proved or assumed that in every other case they *are* intersectors, and Euclid, being unable to prove it, assumes it directly. That is to say, he requires it to be granted that if B S T and S T D be together less than two right angles, S B and T D will meet, if produced, and on that side on which they make with S T the angles less than two right angles. The last clause is not a necessary part of the axiom, since it can be shown, independently of the present theory, that two lines which meet must make angles together less than two right angles with any line which cuts them internally on the side of meeting.



Euclid obviously puts the *whole* difficulty into an assumption; which, though the most direct course, is not that which is best calculated to give the highest degree of evidence to geometrical truths. For it is a more obvious proposition that two lines which intersect one another cannot *both* be parallel to a third line, and this being granted, Euclid's axiom readily follows. If it should be objected that this is merely Euclid's axiom in another form, it is replied that the form is a more easy one, and therefore preferable: just as it would be wiser to assume "Every A is B and every B is A," than the identical but more complicated proposition "Every A is B, and everything which is not A is not B."

It is known then that the difficulty is entirely removed if we grant that "two lines which intersect are not both parallel to any third line," or, which is the same thing, that "through a given point not more than one line can be drawn parallel to a given line." The theory of Euclid being thus improved so far as it is capable of being done by a mere difference of statement, it remains to ask, 1. Whether assumption can be dispensed with altogether, and a direct proof of Euclid's axiom, or something equivalent to it, given? 2. If the preceding question be answered in the negative, can any more simple assumption be made the foundation of the theory?

The attempts to answer one or the other question in the affirmative have been very numerous, and have (without any exception but one in which new axioms of another sort are introduced) tacitly contained the defect which their authors were desirous of avoiding. The author of 'Geometry without Axioms' (General Perronet Thompson) has collected and commented on thirty instances, of which we here make a brief abstract, adding one or two more.

1. The axiom of Euclid in question. 2. Ptolemy; his proof assumes the symmetricality of parallel lines on one side and the other of any line which cuts both. 3. Proclus assumes that intersectors diverge infinitely from the point of intersection, and that parallels do not. 4. Clavius assumes that a line which is everywhere equidistant from a straight line, is itself straight. 5 and 6. Two demonstrations of Dr. Thomas Oliver (1604) assume Clavius's axiom. 7. Wolf, Boscovich, T. Simpson (in the first edition of his Elements), and Bonnycastle, define parallel lines as those which always preserve the same distance, which is Clavius's axiom in the disguise of a definition. 8. D'Alembert would define parallels as lines one of which has two points equidistant from the other, but acknowledged that he could not complete the proof of the axiom of Clavius. 9. T. Simpson (Elements, 2nd edition) proposed to assume that two lines, one of which has two points unequally distant from the other, must meet. 10. Robert Simpson proposed to assume that a straight line cannot first approach to and then recede from another, without cutting it. 11. Varignon, Bezout, &c., would define parallels as lines which make the same angle with a third line: if *a* third line mean *some one* third line, the difficulty remains just as before; if *any* third line, the difficulty is tacitly removed by an assumption. 12. Ludlam, Playfair, &c., recommend the axiom which we have also recommended, namely, that two intersecting straight lines cannot be both parallel to a third. 13. Leslie proposes to attain the same axiom in a sort of experimental manner, by making a line revolve about a point. 14. Playfair (in his Notes) proposes to assume that a straight line which turns completely round, and thus regains its first position, must turn through four right angles, whether it constantly revolves about one point, or whether the pivot of revolution changes. 15 and 16. Franceschini (1787) proposes to assume that the projections of a straight line on a line making an acute angle with it, increase without limit with the projected line. 17. Some have proposed to define parallels as "lines having the same direction," assuming it to be obviously contained in the conception of direction, that two similar

directions make the same angle with any other direction. 18. Mr. Exley (1818) proposes to assume that if four equal straight lines, each at right angles to the preceding, do not meet and enclose a space, a fifth such line would do so. 19. Dr. Creswell proposes to assume that through any point within an angle less than two right angles, a straight line may be supposed to be drawn cutting the two straight lines which contain the angle. 20. Professor Thompson makes it an axiom that "if a triangle be moved along a plane, so that its base may always be on the same straight line, its vertex describes a straight line equal to that described by either extremity of the base. 21. M. Legendre (in the earlier editions of his Elements) makes a direct appeal to the senses. 22. In the seventh edition he assumes (as in instance 15) that a magnitude increases without limit, where perpetual increase is all that is demonstrable. 23. In the twelfth edition he fairly brings the disputed proposition to rest upon the axiom, that if two angles of a triangle diminish without limit, the third (whatever the base may be) approaches without limit to two right angles, a proposition not admissible when, as in M. Legendre's final construction, the base at the same time increases without limit. 24. In a note to the same edition, he demands as an axiom that no straight line can be entirely included between two straight lines which make an angle less than two right angles, which may easily be shown to be nothing more or less than Euclid's axiom. 25. He attemps a proof of the last, which fails. 26. M. Legendre's analytical proof, which we shall presently examine. 27. M. Lacroix would confine the assumption of Euclid to the case in which one of the internal angles is a right angle and the other less. 28. M. Bertrand extends the use of the term equality; we shall afterwards examine his proof. 29. Mr. Ivory assumes a right to construct a series of triangles in a manner which cannot be certainly done unless an assumption as difficult as in (20) be made: and 30, Professor Young makes a modification of the preceding, which does not remove the difficulty.

For further information we may refer to the work from which the preceding abstract is taken. The author of it proposes his own system, the latent assumption of which is, that if equal straight lines make an angle, and other straight lines equal to them be attached to their extremities at the same angle, the remaining extremities of the second pair of straight lines will *not* * always meet.

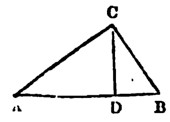
The same author, whose erudition on this subject would alone entitle any attempt of his to attention, has published a new view of the subject, in which he proposes to deduce the properties of the equiangular spiral, and to make them the foundation of a proof of Euclid's axiom. It assumes the doctrine of limits, and the theorem that velocities (in one case at least) are to one another in the limiting ratio of spaces described in the same times. Whatever may be thought of this method as evidence for producing conviction, we cannot take such an assumption as removing the geometrical difficulty, since, by the introduction of a totally new line, it leaps the conventional boundaries of geometry; to say nothing of the question which may fairly arise, as to whether the axioms of the theory of limits are not as difficult as that of Euclid.

Two proofs have been referred to as requiring further explanation: those of MM. Legendre and Bertrand. We take them successively.

The first assumes all that knowledge which is derived from algebra and the theory of algebraical operations. We premise that the theory of parallels may be strictly deduced, though not without some trouble, if it can previously be shown that the three angles of a triangle are equal to two right angles. Let there be a triangle of which the base contains c linear units, and the opposite angle C angular units, the other angles containing A and B units. Then it can be easily shown that any other triangle which has the same base c and the same adjacent angles A and B must be in all respects equal to the first: that is, c, A, and B being the side and adjacent angles of a really existing triangle, C is given when c, A, and B are given. There must then be some algebraical mode of expressing C in terms of c, A, and B, such as

$$C=\phi(c, A, B).$$

From such an equation, if it exist, c can be found in terms of A, B, and C, that is, the length of a straight line can be expressed by means of angles only. Now it is known that no equation can determine a magnitude by means of magnitudes no one of which is of the same kind with it: and the only way of avoiding this supposition is by supposing that c does not enter the equation at all, or that $C=\phi(A,B)$, so that the third angle of a triangle is given when the other two are given, whatever the side may be, *provided the triangle be known to exist.* Let there be a right angled triangle ACB, and let CD be perpendicular to AB; then the triangles ACB, ACD, have a common angle at A, and a right angle in each: consequently their third angles are equal, or ACD = ABC. Similarly DCB = CAB; whence the angles at A and B are together equal to a right angle. And if the two acute angles of a right angled triangle be equal to one right angle, it is readily shown that all the three angles of any triangle are equal to two right angles.

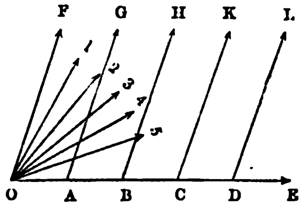


It is not our intention to go fully into the objections which have been made to this proof, nor into Legendre's answers; all which may be found in the notes to Sir David Brewster's translation of Legendre. It has the disadvantage of being founded upon a science which requires more and harder axioms than geometry itself, and of which the particular process employed, namely, inversion of a function, is in many cases full of unexplained difficulties; while it has the advantage of not appealing to any new notions of space. As an illustration of the connection between algebra and geometry, it must always be valuable: but we suppose no one would think of making it the foundation of geometry. Some objectors imagined that Legendre would infer that a base c, with two adjacent angles together less than two right angles, must be the base of a triangle; or that because the formula applies wherever there is a triangle, that there must be a triangle wherever the formula applies. If this were the case, undoubtedly they were right in saying that Legendre did in fact assume Euclid's axiom: but if, as we apprehend, he would have applied the proposition thus proved of existing triangles, to the proof of Euclid's axiom, he should certainly have stated his intention more distinctly in his reply. It seems to us that he took it as admitted on all sides how to deduce Euclid's axiom, while his opponents imagined that he considered himself as having proved that axiom.

It is of much importance, in connection with Legendre's view, to remember the point mentioned at the end of ANGLE, namely, that angle, of all magnitudes, is the only one of which number is a function, and the converse.

The proof of M. Bertrand is as follows:—Let it be granted that two spaces, *whether finite or infinite*, are equal,* when one can be placed upon the other so that any point whatsoever of either lies upon a point of the other: that is, let it be legitimate to say, of the word equal as thus used, that spaces which are equal to the same space are equal to one another. Granting this, it is easily shown—1, that the infinite spaces of equal angles are equal; 2, that of two angles, the infinite space contained in the greater is greater than the infinite space contained in the less.

Let there be two lines, OF, AG, making with OA internal angles FOA, GAO, equal to two right angles. Then OF and AG are parallel.



Take AB, BC, CD, &c., each equal to OA, and make the angles HBC, KCD, LDE, &c., all equal to FOA or GAB. Let all lines with arrowheads be produced without limit in the direction to which the arrowhead points. Then if OA be placed on AB, the lines OF and AG will in their new positions coincide with AG and BH, or the infinite space FOAG is equal to the infinite space GABH: and similarly HBCK, KCDL, &c., are all equal to one another and to FOAG. But it is obvious that no number of these spaces, however great, will fill up the infinite space of the angle FOE. Now let a line O 1 be drawn in such a manner that 1 O A and GAO are together less than two right angles; whence O 1 falls nearer to OE than does OF. Take FO 2 double of FO 1, FO 3, treble of FO 1 and so on: whence, since of two quantities which bear a ratio, the less may be multiplied so as to exceed the greater, some multiple of FO 1 must be greater than FOE, whence some multiple of the infinite space FO 1 is greater than the infinite space FOE. But no multiple of FOAG will be so great as FOE; whence the infinite space FO 1 must exceed the infinite space FOAG. Therefore O 1 produced must cut AG; for if not, the space FO 1 would be entirely contained in FOAG, and the former could not exceed the latter.

We have not noticed the numerous attempts at the solution of the difficulty which proceed by tacit assumption or illogical process, under the pretence of avoiding the axiom of Euclid, without substitution of any other. We shall conclude this article with an account of a result contained in a paper, by Legendre, in the 12th volume of the 'Memoirs of the Institute,' being his latest attempt at the solution of the problem. It is what he properly styles a geometrical translation of the analytical proof already noticed, and its chain of reasoning proceeds through three propositions.

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* In the edition of 1833, this assumption was explicitly made. A writer in the 'Journal of Education' (vol. vii. p. 105) having pointed this out, the words "provided the straight lines do not meet" were added (in the edition of 1834) to the enunciations of the leading propositions of the proof. This certainly removes the difficulty from the propositions themselves, but throws it upon their consequences; and the final result only remains proved, provided those lines do not always meet: that is, the proposition that they do not always meet, still remains an axiom. The work is well worth the perusal of the student, though we have no doubt whatever that in respect to the theory of parallels it is no amendment of Euclid.

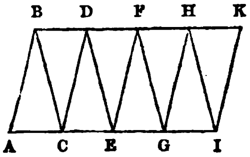
* The author of 'Geometry without Axioms' cites Plato for the axiom that equality is only to be predicated of finite magnitudes. But withou tlooking at the authority of Plato, or any one else, it is for the reader now to ask himself whether he can, by comparing the infinite spaces contained in equal and unequal angles, obtain a distinct conception of equality, of greater, and of less: if so, the proof of M. Bertrand must be admitted by him; if not, no one has a right to demand his acquiescence. We are inclined to think that it *is* a proof to some, but not to others; to us it certainly is a proof. But we do not contend for the admission of considerations respecting infinity into elementary geometry: we should hold such a plan altogether opposed to every principle of sound teaching.

1. It is impossible that the sum of the angles of a triangle can in any case exceed two right angles.

2. If there be any one triangle which has angles together equal to two right angles, the same must be true of all triangles.

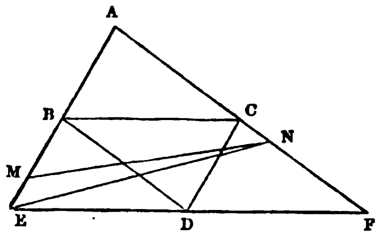
3. If the angles of a triangle be not equal to two right angles, then angles alone may be made to determine a straight line.

1. If it be possible, let there be a triangle BAC having its angles together greater than two right angles. In AC produced take CE, EG, GI, &c. each equal to AC, and make the angles DCE, FEG, &c. each equal to BAC, and let CD, EF, &c. be each equal to AB. Join BD, DF, &c.



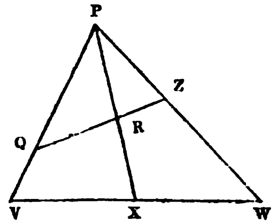
which are not known to be in the same straight line, though they are so. Then the triangles DCE, FEG, &c. are severally equal in all respects to BAC. And because the angles at A, B, C, are together (by hyp.) greater than two right angles, and two of them are equal to two of the angles at C, it follows that the angle ABC is greater than BCD, whence AB and BC being severally equal to DC and CB, it follows that AC is greater than BD. Similarly CE is greater than DF, &c., whence AI exceeds BDFHK by as many times the excess of AC over BD as AC is contained in AI. Now however small this excess may be, it may be multiplied until the multiple exceeds twice AB, or AB and KI together. That is, AI, one side of a figure, may be made greater than AB, BD, DF .... KI, the sum of all the other sides; which is absurd. Hence, it is not true that the angles of any triangle are together greater than two right angles.

2. Let there be any one triangle ABC in which the sum of all the angles *is* two right angles. Make the angle BCD=ABC, and CBD=ACB, whence the triangle BDC is in all respects equal to ABC. Produce AB and AC each to double of its length, and join E, D, and DF. The angle CBE being equal to BAC and ACB together, and CBD being=BCA, it follows that EBD=BAC; whence the triangle EBD is in all respects equal to BAC, and the same, for similar reasons, is DCF. Hence the three angles at D are severally equal to those of the triangle ABC, or to two right angles; and thus EDF is a straight line, and AEF a triangle equiangular with ABC, and therefore having angles equal to two right angles. Or, if there be any such triangle, there is another of the same sort with double sides and the same angles; and since this process of doubling the sides may be repeated to any extent, it follows that, if there be any other given triangle, a triangle can be found with longer sides, and having the sum of its angles equal to two right angles.

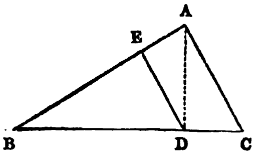


Next, any triangle AMN which has the angle A, must have the sum of all its angles also equal to two right angles. Continue the preceding process until the triangle AMN is completely inclosed, say in AEF, and join E, N. Then all the angles of the three triangles AMN, MNE, NEF, make up the angles at A, E, F (two right angles), those at M (two right angles), and those at N (two right angles); six right angles in all. Consequently each set of angles, in each triangle, must be equal to two right angles; for all three sets making up six right angles, no one set can fall short of two right angles, without another set exceeding it, which has been shown to be impossible.

Lastly, on the preceding assumption (namely, that there is one such triangle), *every* triangle has the sum of its angles equal to two right angles. Let ABC be the one triangle, as before, and let PQR be any triangle not equiangular with ABC; one of its angles must be less than one of the angles of ABC; for if not, the sum of the angles P, Q, R would be greater than that of A, B, C, or greater than two right angles. Let it be that P is less than A, and make QPZ equal to BAC, constructing, by the preceding process of doubling the sides, a triangle VPW containing PQR. Then since PVX has an angle (at V) common with PVW, the angles of PVX are together equal to two right angles, and because PVX has an angle in common with PQR, the angles of PQR are also equal to two right angles. Hence, if any one triangle have its angles equal to two right angles, the same must be true of all triangles whatsoever.



3. If then we deny the preceding truth in the case of any one triangle, we must deny it in the case of all. Let it then be universally denied; and, taking any triangle ABC, take a point D, at which make the angle BDE=BCA. Then the angle BED must be greater than BAC; for if not, DEA and EAC are at least equal to two right angles, and, EDC and ACD being together equal to two right angles, the angles of the triangles EDA, ADC, are together at least equal to four right angles, which is denied. For it is denied that either set is equal to two right angles, and it has been shown that neither set can be greater. In like manner it may be shown that if D move from C to B (the angle BDE being always=BCA), the angle BED must continually increase, and can therefore only have a given value for a thereby determined value of BD. That is, by assigning the angles B, D, E, the side BD can be absolutely laid down. Now since angles might be given in numbers (taking the right angle, which is absolute, as a unit), it therefore follows that the length of a straight line might be handed down from generation to generation, by means of numbers only, without any dependence on a *linear* unit. This is the same conclusion as follows from the analytical proof, against those who would deny its conclusions.



We consider the preceding process as containing the most remarkable addition which has been made to the theory. With regard to the whole question, we do not consider the difficulty as one of a different kind from that of the quadrature of the circle or the trisection of the angle. In the earlier stages of mathematical investigation, all that was not evidently impossible was attempted, and failure was, properly and modestly, attributed to the want of sagacity in the investigators. In the instance before us, the object was to deduce positive properties from a purely negative definition, involving, be it observed, the idea of infinity. For if we say that parallels are lines which never meet, however far produced, we must, in the hypothesis "let AB and CD be two parallel lines," contemplate every point of both, however remote from A and B. The demonstration of M. Bertrand appears to us to assume considerations which are indispensable to the direct treatment of this negative definition; nor can we imagine the positive deduction of properties from the assumption of lines which never meet, without making their intervening space, as compared with other spaces, an object of reasoning. And even if the preceding process of M. Legendre should be allowed, so far as proving that one triangle only need be shown to have the sum of its angles equal to two right angles, and should the final theorem be ultimately completed by a less objectionable third process (of which we do not entirely despair), it may be doubted whether right reasoning will be promoted by the arbitrary rejection of notions intimately connected with those which are necessary for the perfect conception of a definition. On this the whole question must at last turn: it will readily be granted that a studied exclusion of a particular figure (for instance, of the equilateral triangle) would be no real gain to the strictness of geometry, even though it should be shown that the whole of Euclid might be established without it. The new considerations brought forward by M. Bertrand have not yet received the degree of attention which we will venture to prophesy must yet be given to them. When they have been maturely discussed, the following question will arise:—In admitting the notion and definition of parallels, and rejecting the comparison of their intervening spaces with angular spaces, are we, or are we not, in the position of those who admit one notion, while they exclude another which is as much of kin to the first as that of an equilateral triangle to any other triangle? We should be sorry to see this question settled either way without such an examination of the nature of our ideas of magnitude, and in particular of the connection of finite and infinite, as has not yet been made. But even if our question should be resolved in the affirmative, it does not follow that comparisons of infinites can be successfully introduced into elementary teaching.

PARALLELS, in the attack or siege of a place (SIEGE), are wide trenches affording the besieging troops a free covered communication between their batteries and approaches, and a protection for the guard of the trenches and the covering parties in the day time. What were in former times termed lines of contravallation are now termed parallels. There are usually three or four parallels made in the attack of a place, though of course the number will depend wholly on the strength of, and the artillery possessed by, the garrison; the saliency of its main works, and of its outworks and detached works, should it possess any; the vigour of the defence and the nature of the ground in the neighbourhood, whether providing good natural cover for bodies of covering troops or not. Though the siege of different places will vary much according to these points, methods of attack are laid down in works on fortification on certain assumptions, in order to give an idea of the general method, and from which to deduce a standard of strength of different systems. In these there are generally three parallels; the first at 600 yards from the place, another at about 300 yards, and a third at the foot of the glacis. The second parallel is constructed by *flying sap*, the third by regular sap, while the first, being supposed out of the range of musquetry, grape-shot, and canister, by ordinary trench-work. These distances and methods may be much modified in practice, especially by the introduction of arms of precision, but as an assumption either for instruction or for comparing different systems they are still retained. The method of tracing, &c., will be found under SIEGE.

PARALYSIS (a Greek word, *παράλυσις*, which signifies literally a "loosening" or "relaxation") is the diseased condition in which the natural power of sensation or motion is lost in any part of the body.

The principal forms of paralysis are dependent on the fact that although most of the nerves distributed through the various parts of the body contain filaments for performing the functions of motion and sensation within the same sheath, yet the two orders of filaments are distinct in their origins and arise from separate portions or tracts of the brain and spinal chord. If a sensitive nerve, or the tract of nervous matter from which the sensitive nerves of any part arise, be destroyed or seriously diseased, there will be a loss of sensation in that part, but its natural power of motion will remain; if the same injury befal a motor nerve, or a centre of origin for motor nerves, the part supplied therefrom will lose its motion, but retain its sensibility; and if a mixed nerve, or both nervous centres simultaneously, be affected, there will be a loss at once of sensation and of motion. Hence we have two distinct kinds of paralysis—loss of sensation, which is sometimes called *anæsthesia*, and loss of motion, to which the term paralysis, or palsy, is by some exclusively applied.

Each of these varieties of paralysis may vary in its degree of severity, or in the extent of the part of the body which it affects. For example, either kind may be *complete* or *incomplete*: in the former, the sensation or loss of motion, or both, are completely destroyed; in the latter, they are only impaired. In its varieties of extent, paralysis of sensation may affect either a single nerve, as in loss of sight when dependent on disease of the optic nerve [AMAUROSIS]; in loss of smell, or anosmia, from affection of the olfactory nerve; in deafness, from disease of the auditory nerve; and loss of taste, from disease of the nerves appropriated to that function: or it may affect the sensitive nerves of a limb or of a variable portion of the body. In like manner paralysis of motion may affect a single muscle, as in *ptosis*, or dropping of the eyelid, from disease of the third nerve; or it may occur in a part of the muscles of the face, or the muscles of one or more limbs, or of a part of the trunk and limbs. Lastly, whole regions of the body may be paralysed; and of these cases the chief varieties are, *hemiplegia*, in which one side—half of the body—is deprived of sensation or motion, or of both; *paraplegia*, in which the lower part of the body is paralysed, while the upper retains both sensation and motion; and general paralysis, in which the loss of nervous power extends over nearly every part of the body.

Other varieties of paralysis are described from peculiar circumstances in their cause or symptoms; as *lead*-palsy, which is produced by the influence of lead, either locally applied, as to the hands of painters, or received into the system generally; *creeping*-palsy, which, commencing in a limited part of the body, gradually extends over a large portion of it; *shaking*-palsy, in which the loss of motion being incomplete, any attempt at its exercise is effected by a trembling unsteady action, like that of a fatigued muscle.

The conditions under which these various forms of paralysis arise are numerous. Its most common and general causes are those which mechanically destroy that condition which is essential either to the conduction of sensitive impressions to the brain and to their perception by the mind, or to the conveyance of the stimulus of the will through the nerves of motion to the muscles. Thus pressure on the brain, by a fracture and depression of the skull [HEAD, INJURIES OF], or by a large effusion of blood [APOPLEXY], or by large tumours, or an excessive fulness of the arterial or venous system of the brain [ENCEPHALITIS; MENINGITIS] may, by preventing the free circulation of the blood through every part of its substance, produce general paralysis. Disorganisation of the brain by softening or other excessive change of structure has the same effect, but often in a less degree, producing not a complete loss, but an impairment of nervous power. Injuries of the same kind affecting only one side of the brain produce hemiplegia, the loss of power existing on the side of the body opposite to that on which the brain is compressed, in consequence of the decussation of the nerves which takes place at the medulla oblongata. [BRAIN, NAT. HIST. DIV.]

In like manner a similar compression of the spinal cord in any part will produce a paralysis of all the parts of the body whose nerves come off below the level of the injured part; and a similar obstruction applied to a single nerve will affect only that part which it supplies. The effect is the same, whatever be the nature of the cause preventing the performance of the functions of the nerves or their centres; the results of each differing only in the suddenness or slowness, or the degree of intensity with which its symptoms are produced.

There are some other but rarer and generally less serious cases of paralysis, in which no material change is discoverable in the structure of the nervous system. These are called functional or idiopathic paralysis; but it may be reasonably doubted whether they do not all, or for the most part, depend on some alteration not yet discovered, and perhaps inappreciable by our present means of investigation. Such cases occur in some anomalous forms of nervous diseases, as in hysteria, and appear to be connected by sympathy with disorder of the uterine or digestive functions; they are also not unfrequently produced by the introduction of poisons, as in those who work with lead or mercury.

General paralysis, in which all sensation and voluntary motion are impaired or lost, is most commonly the result of apoplexy, or of severe injury to the head, producing concussion or compression of the brain; and indeed it may be said to exist in all cases of complete coma, or insensibility. More rarely it is produced gradually; the patient losing in succession the power of motion in all his muscles, and at last existing only with an internal life, but disabled from all active communication with the external world. This state is usually the result of disease of the brain or spinal cord gradually spreading through their substance; and especially of disease of the latter spreading upwards. It not unfrequently comes on in the inmates of lunatic asylums.

The most frequent if not the only cause of paraplegia is injury or disease of the spinal cord; and this may originate in its own structure, or be produced by injuries or diseases of the vertebral column or other parts surrounding it. Paraplegia, when the result of disease, commonly affects first the lower extremities and the parts below the level of the haunches, because the first part affected in the greater number of diseases is the lower portion of the spinal cord, from which the nerves supplying the lower extremities and pelvic organs are derived. When produced by injuries of the vertebral column however, the paraplegia may from the first affect the body to a much higher level; its extent being always determined by the height in the vertebral column at which the injury is inflicted. In either case the disease, whether original or consequent upon injury, tends to spread up the cord; and with a corresponding progress, the paralysis rises up the trunk, and affects successively the chest and arms, terminating in death when the disease has reached the origin of the phrenic nerves, upon which the movements of the diaphragm depend.

In this form of paralysis, when all sensation and voluntary motion are destroyed, involuntary movements are produced by irritating the skin of the insensible parts. These motions depend on the reflex action of the spinal cord [NERVOUS SYSTEM, NAT. HIST. DIV.]; the power of conducting impressions to and from the brain is lost, but the power which the cord possesses of exciting motions when impressions are made upon it, remains. The patient thus affected is indeed, as far as his nervous system is concerned, in the same condition as a beheaded animal; and the actions produced by irritating the parts below the divided or injured portion of the cord are of the same kind as those observed after decapitation.

In paraplegia the parts deprived of nervous connection with the brain are, even more than in any other form of paralysis, liable to mortification when long subjected to pressure; and hence the sloughing of the back, which so commonly tends to shorten the patient's life. The sensibility to the pain produced by long-continued pressure being destroyed, the patient would not be inclined, even if he were able, to make those frequent changes of position by which a healthy person avoids its dangers.

Hemiplegia, in which the paralysis is confined to one side of the body, usually affects (as paraplegia does) the sensitive and the motor nerves simultaneously. This is by far the most frequent form of paralysis, and is that by which those popularly called paralytic are usually affected. Hemiplegia generally occupies exactly one-half of the body, the middle vertical plane separating the healthy from the paralytic portion. It is at once easily recognised in any patient by the flatness and smoothness of the affected side of the face, by the angle of the mouth being drawn over towards the opposite side, and by a general *wry* position of the features. The arm hangs powerless by the side; and in walking, the patient drags the affected leg after him, or, raising it from the ground by depressing the opposite side of the pelvis, lets it swing forward with its toe pointed towards the ground like a pendulum. Hemiplegia is most frequently the consequence of apoplexy [Apoplexy], remaining after the patient has recovered from the complete insensibility or general paralysis by which the seizure was at first followed. More rarely it appears to rise from congestion or disorganisation of the brain, and is not preceded by any fit, but is developed by degrees from slight to perfect loss of nervous power.

The varieties of paralysis, in which single and small portions of the body are affected, do not in general continue permanently limited to the part first attacked, but are often precursors of the more general affections already described. The most important forms, and those in which the paralysis most frequently remains for a long time local, are those in which the eyelids or muscles of the eye, and those in which the muscles of the face, are affected.

In paralysis of the muscles of the eye, the most commonly affected are the elevator of the upper eyelid and the orbicular muscle of both the eyelids. When the former loses its power, the eyelid drops, and the eye is constantly more or less closed; when the latter is affected, the eye cannot be shut, and remains permanently wide open. The dropping of the upper eyelid (or ptosis) is dependent on a disease or injury of the third pair of nerves, and is usually accompanied by a paralysis of some of the muscles of the eyeball which are supplied by the same nerve; so that the position of the eye is altered, or it cannot be freely moved. The permanent openness of the eye is the result of disease of the seventh or facial nerve, or of its branch supplying the orbicular muscle; sometimes this latter branch alone is implicated; but more frequently the whole trunk is affected, and there is coincident paralysis of all the muscles of the face. As far as regards their influence on vision, both cases are almost equally injurious; the first by placing a veil constantly over the front of the eye; the second by destroying the power by which particles of dust, &c., are removed from the surface of the eye, and thus leaving it exposed to the dangers of constant irritation and inflammation.

In paralysis of the face many different conditions are observed, according to the nerve which has been diseased or injured. The sensation of the face depends entirely on the sensitive or larger portion of the fifth pair of nerves [Brain, in Nat. Hist. Div], the motion of its muscles on the seventh or facial nerves, and the motion of the muscles of mastication on the motor or small portion of the fifth pair. Now if either of these three nerves or their sources in the brain be separately injured, the paralysis will be limited to a loss of sensation, a loss of the motion of the muscles of the face, or a loss of the motion of those of the jaw, on the side affected. In the most frequent cases of affection of the fifth nerve, both its sensitive and motor portion are injured, and there is both a loss of motion of the muscles of the jaw and a loss of sensation of the whole of the skin of one side of the face.

Lastly, a limb, or a part of a limb, or a single muscle or set of muscles in any part of the body, may be paralysed. In some cases such an affection is only a sign of disordered digestion, and thus they occur chiefly in children; in others it exists in what is called general nervousness, as in hysterical women, who, with many other strange disorders, sometimes lose the power of swallowing or speaking. Most frequently, however, these forms of local paralysis depend on injury of the nerves of the part, which are compressed by tumours or involved in some diffused disease.

An important class of local paralytic affections includes those in which recent investigations have detected the sources of many cases of congenital or acquired deformity, such as club-foot, curvature of the spine, squinting, &c. In these, one or more muscles of a limb or organ being from birth or from childhood weak or powerless, its antagonist muscles draw the part into an unnatural position, and hold it there firmly and permanently fixed. One of the most important achievements of modern surgery is the cure of these affections by the division of the contracted muscle or its tendons. [Contraction.]

These, however, are the only cases in which general rules of treatment can be laid down. The varieties of causes from which paralysis may arise, afford sufficient evidence that its treatment in different cases must vary greatly. It cannot indeed be said to be a disease of itself, since it is only a sign of some disorder of the nervous system, which is often seated at a distance from the part whose motion or sensation is lost. This disorder, also, is of no definite kind, but may be the result of hæmorrhage, or inflammation, or slow structural change of the nervous substance; or it may be produced by the pressure of fractured bones, or tumours, &c. In each case, therefore, the cause of the paralysis must be treated before there can be any expectation of removing its effects.

PARA'METER. This term was first used in reference to the conic sections only, in which it was synonymous with latus rectum; that is, the perpendicular drawn to the axis through a focus, terminated both ways by the curve, was the parameter of the curve. It was afterwards used to denote any straight line or even numerical co-efficient, by the value of which one individual curve of a species may be distinguished from the rest. Thus the curve whose equation is $y=ax+bx^3$ has two parameters, a and b. This last phraseology was never in very general use, and is now preserved only in questions in which what is called the variation of parameters is to be employed. Thus when in the planetary theory the motion of a planet is ascertained by determination of the variation of the instantaneous ellipse [Gravitation; Orbit], and of the motion in that ellipse, in contradistinction to determining the motion in longitude and latitude separately, the method of variation of parameters was said to have been employed. But the *parameters* of the orbits are now generally called their *elements*; and the first term is little used in astronomy, though it occurs frequently enough in works on the differential calculus to require notice in a work of reference.

PARAMIC ACID. This name has been given to a white crystalline precipitate obtained by dissolving paramide in ammonia and then pouring the solution into hydrochloric acid. Its composition and even its existence are somewhat doubtful.

PARAMIDE (C_8HNO_4), *Mellimide*, is formed when mellitate of ammonia is heated in a retort to about 320°. It is accompanied by another body called *euchroic acid*. Paramide is a solid yellow substance, which when long boiled with water is changed into a bimellitate of ammonia.

PARAMORPHIA, *paramorphine*. [Opium, Alkaloids of.]

PARAMOUNT. [Title.]

PARAMUCIC ACID. [Mucic Acid.]

PARANAPHTHALIN. [Naphthalic Group.]

PARAPET (from the Italian *parapetto*, compounded of the Greek preposition *παρὰ*, "against," and *petto*, "breast;" in German, *brustwehr*), a low or breast-high wall or fence, to serve as a protection on bridges, terraces, platform roofs, &c. In Italian architecture, parapets are generally balustrades. In Gothic architecture, the parapet is a continuation of the wall carried up above the edge of the roof, and finished by a coping; unless machicolated, in which case it projects and overhangs the walls below. [Machicolation.] In the Romanesque buildings of Italy there is seldom any parapet, the eaves of the roof finishing the elevation. The same is frequently the case in the Norman style, or else the parapet is quite plain; whereas in Pointed Gothic it is commonly embattled, even in ecclesiastical buildings, and both the battlements and the crenelles or spaces between them have usually moulded copings. In the Third Pointed or Perpendicular style, parapets and battlements are either pierced or enriched with panels. East Basham manor-house is a fine specimen of such decoration in domestic architecture. (Pugin's 'Goth. Examples,' vol. i.) The perforated or open-work parapets of quatrefoil ornaments and other carved patterns often form a very rich feature in ecclesiastical and collegiate buildings of Third Pointed date. At a later period instances occur of open-work for such purpose, forming the letters of some motto, date, or inscription. In Elizabethan buildings open-work parapets, forming various fantastical devices, are common.

PARAPET, in Fortification, is generally an embankment of earth which is formed either on the natural ground or on the upper surface of the rampart of a fortress or outwork. In the latter case the parapet rests on that part of the rampart which is nearest to the exterior of the work, the terreplein, or nearly level part on the interior side, being occupied by the artillery or left free for the movements of the defenders. Parapets of brick or stone are sometimes constructed for works which are masked by others in their front, or on heights, or on the sea-coasts; but in other circumstances they would be improper, because the splinters detached from such materials by the enemy's shot are dangerous to the defenders, whereas the shot sinks into earth without doing further mischief.

The height of a parapet above the ground, or above the terreplein of a rampart which it surmounts, is about 7½ feet, in order that it may effectually cover the defenders behind it. In its mass are cut the embrasures through which the guns are fired; and a banquette, or step, about 3 feet high and 4 feet broad is formed, usually of earth, at its foot, on the interior side, in order to enable men, by standing on it, to fire over the upper surface. The form of a transverse section of a rampart, surmounted by a parapet, is represented in *fig.* 2, Bastion; the parapet with its banquette being that which occupies, on the right hand side of the figure, rather less than the upper half of the space between the dotted lines.

The exterior face of a parapet of earth is generally formed in a plane making an angle of 45 degrees with the horizon, in order that the earth may stand unsupported; the superior surface, which varies in breadth from 3 feet to 25 feet according to the nature of the shot which it is intended to resist (from musket bullets to the balls discharged from the heaviest ordnance), has its exterior crest or edge lower than the other by about one-sixth of the breadth of that surface. It is recommended that the depression of the slope should not bear a greater proportion to the breadth, lest the upper part of the parapet should by its acuteness be weakened; but the general rule is that the plane of the superior slope should, if produced, meet the counterscarp line of the ditch in front, in order that the enemy, at the time of an assault, and when detained by the obstacles there, may be completely exposed to the fire of musketry from the parapet. The interior face of the parapet is frequently formed in a plane passing through the crest, and, at the terreplein of the banquette, or at the foot of the parapet if there is no banquette, deviating from a vertical plane passing through the same crest about one-third of the height of the slope. By this inclination the earth, when reveted with fascines or sods, and even without any revetment, will support itself for a time, while a man, by leaning a little forward, is enabled without inconvenience to fire over the parapet.

Occasionally parapets of field-works have been formed with the earth obtained by excavating the ground in the interior; and, in this case, the crest of the parapet may be only 3 or 4 feet above the exterior ground. Such a construction is admissible, however, only when the site of the work is several feet higher than the ground which the enemy may occupy, since otherwise the defenders, except when close behind the parapet, would be exposed to his fire. Again, should the ground about the spot to be fortified be higher than that spot, the crest of the parapet must have a greater height than 7½ feet, in order that the defenders may be sufficiently covered by it: but in general the parapets of field-works cannot be raised more than 14 feet above the ground; since a man can scarcely throw earth with a spade to a greater height than 7 feet, and a greater height than 14 feet would require, above ground, more than two rows of shovellers, one row 7 feet above the other, besides one row, or two rows, at an equal interval in the ditch; and it is seldom that the numerical strength of a working party is sufficient to allow such a disposition to be made.

The earth used for forming the parapets should be as free as possible from stones or gravel, or these should be put into the centre of the mass, in order to avoid the accidents which might arise from the dispersion of the stones when shot or shells strike; and the slopes, as well as the banquettes, when time permits, should be covered with turf.

PARAPHERNA'LIA. This term comprehends the dress and ornaments of a wife which she occasionally wears, and which she is entitled, under some limitations, to retain after her husband's decease. It cannot be accurately stated how much a wife may claim as her paraphernalia, for this will depend on the rank and fortune of the husband and wife. A widow is entitled to retain as paraphernalia ornaments which she has received from her husband, provided she has worn them occasionally. The wife cannot give or bequeath such paraphernalia during her husband's life, nor can her husband bequeath such paraphernalia so as to deprive her of them; but he can sell them or give them. The wife's paraphernalia are liable to the payment of the husband's debts, unless the articles were given to her by a stranger before marriage or after marriage: in such case the articles are considered as gifts to the separate use of the wife, and are accordingly neither at the disposition of the husband nor liable to the claims of his creditors; but if such gifts are to be considered as the separate estate of the wife, they are not properly paraphernalia.

The widow is entitled to her paraphernalia in preference to any claim of legatees; and if specialty creditors of her husband have taken her paraphernalia for payment of their debts after the personal estate is exhausted, she has a right to reimburse herself out of the real estate which has descended to the heir.

The term paraphernalia is derived from the Greek *parapherna*, a term which the Roman lawyers adopted to express what in their own language could not be expressed by a single word, and which was expressed by the periphrasis of *præter* or *extra dotem*. The parapherna comprised the things which the wife brought to the husband's house, and which were not part of her *dos*. The common practice at Rome was for the woman to make out a list of such things as she used, clothing, &c., which list was signed by the husband, as an acknowledgment of receiving them, or at least of receiving them into his house. This practice, derived from the Roman law, is still in use in some countries of Europe. The husband did not obtain the ownership of the things included in such list, and in case of a separation, they were restored to the wife: if they were not restored, she could recover them by an action framed according to the circumstances of the case. ('Dig.,' 23, tit., 3, s. 9.) It must be remembered that the Roman *dos* is a different thing from the English *dower*, though some English writers on law have confounded them. (Roper, 'Law of Husband and Wife,' "Paraphernalia.") [Marriage.]

PARAPHRASE (from the Greek *παράφρασις*). A paraphrase partakes of the nature both of a version, if the work paraphrased be in a foreign language, and of a commentary. Its object is to express the full sense contained in the words which are paraphrased, by the introduction of circumlocutions, explanatory clauses, and expansions of the author's meaning. A paraphrase, if well and honestly executed, is an excellent mode of giving a connected interpretation of a whole work. The faults to which this sort of commentary is most liable are an alteration of the author's sense, and a degree of weakness and tediousness resulting from the use of unnecessary words.

PARAPLEGIA. [Paralysis.]

PARASANG (*ὁ παρασάγγης*), a Persian measure of length, which, according to Herodotus (ii. 6; v. 53; vi. 42), was equal to 30 stadia and if we reckon eight stadia as equal to one English mile, the parasang was consequently equal to nearly four English miles. Hesychius and Suidas also give the length of the parasang at 30 stadia; and Xenophon must have calculated it at the same length, as he says ('Anab.,' ii. 2, s. 6) that 16,050 stadia are equal to 535 parasangs (16,050÷535=30). Pliny ('Hist. Nat.,' vi. 30), however, informs us that the length of the parasang was reckoned differently by different authors; and Strabo states (xi., p. 518, Casaubon) that some reckoned it at 60, others at 40, and others at 30 stadia. The Arabic geographers (see Freytag, 'Lex Arab.,' sub Farsakh) reckon it equal to three miles. The Rev. G. Rawlinson remarks (in a note in his edition of Herodotus, 1859), that the parasang, like the farsakh, was originally a measure of time, not of distance, and consequently varied according to the nature of the country passed over. He agrees, however, in the general conclusion that it averaged about three and a half to four English miles.

Parasang is a Persian word, and is derived from the ancient farsang, which is pronounced in modern Persian, ferseng. It has been changed in Arabic into farsakh. Various etymologies of this word have been proposed. The latter part of the word is supposed to be the Persian *seng*, a stone, and the word might thus be derived from the stones which were placed to mark the distances in the road. Bohlen (quoted by Rödiger) supposes the first part of the word to be the preposition *fera*, and compares the word with the Latin *ad lapidem*.

PARATHERMIC RAYS. Photographic processes are considerably expedited by the application of a gentle heat, and the active agent is supposed to consist of rays which are found in and below the red and orange of the solar spectrum, and which are emitted by bodies heated just below redness. These parathermic rays probably bear the same relation to the true calorific rays as those which produce chemical phenomena do to the luminous rays.

PARATHIONIC ACID ($C_4H_6S_2O_8$). An acid of little importance, isomeric with sulphovinic or ethyl-sulphuric acid. [Ethyl.]

PARATONNERRE. The French term for a Lightning Conductor.

PARCÆ (*Μοῖραι*), the Fates, were goddesses who were supposed to preside over the destinies of man. In Homer we only read of one deity, *Μοῖρα* or *Αἶσα*; but in Hesiod and all succeeding poets we read of three Fates: Clotho (*Κλωθώ*), the "Spinster;" Lachesis (*Λαχέσις*), the "Distributor;" and Atropos (*Ἄτρωπος*), the "Unchangeable." In one passage Hesiod ('Theog.,' 904) calls them the daughters of Zeus and Themis; and in another ('Theog.,' 217), the daughters of Night, which agrees with the statement of Cicero ('De Nat. Deor.,' iii. 17), who makes them the daughters of Night and Darkness (Erebus). This contradiction seems to have arisen from the different notions entertained by the ancients respecting the relative power of Zeus and the Fates, since they were sometimes represented as ruling the gods and Zeus himself, and at other times as merely carrying into effect the determinations of Zeus. In the ancient Greek writers, and especially the tragic poets, the gods themselves are represented as subject to the decrees of fate; but in later times the Fates appear to have been generally regarded as subject to Zeus. Thus we learn from Pausanias (v. 15, s. 4; x. 24, s. 4) that Zeus was worshipped both at Olympia and Delphi under the name of *Μοιραγέτης*, or "Leader of the Fates," which title was also applied to Apollo at Delphi. (Paus., x. 24, s. 4.) Pausanias, in describing (i. 40, s. 3) a celebrated statue of Zeus at Megara, on the head of which the Fates (*Μοῖραι*) were placed, remarks that this was done because destiny (*τὴν πεπρωμένην*) is obedient to Zeus alone.

The Fates are usually spoken of by the Greek and Roman poets as spinning the destinies of men ('Il.,' xx. 128; 'Od.,' vii. 197); and according to mythologists, each of the three presided over different periods of human life: Clotho over the beginning, Atropos the end, and Lachesis the general course of the life of each individual. Apuleius ('De Mundo,' p. 280, Bipont), whose opinion however can scarcely be regarded as representing the popular belief upon the subject, assigns a different office to each of the Fates. Atropos he regards as the Fate of past time, Lachesis of future, and Clotho of present events. In Greek art the Fates are sometimes represented as matrons winged. In some instances Atropos has a style, holds scales, or points to the hour on a sun-dial, or is cutting the thread of life; Clotho is spinning; Lachesis holds a roll, or is writing.

There was a temple at Lacedæmon sacred to the Fates (Paus., iii. 11, s. 8), and there were also altars sacred to them in the neighbourhood of Sicyon. (Paus. ii. 11, s. 4.) They had also in later times a small temple at Rome in the eleventh district (regio) of the city (Onuphr. Panvin. apud Rosin., i., c. 13); but their worship seems to have prevailed at Rome to a very small extent.

PARCENERS, or COPARCENERS, are so called because the lands of which they are parceners may be partitioned or divided among them. There may be parceners by common law and parceners by custom.

As to parceners by common law, if a man dies intestate seised of lands in fee, and leaves only daughters, the lands will descend equally to all the daughters; or if he has no daughters and no brothers, the lands will descend equally to all his sisters, if he has any; and if there are no nearer heirs, the lands will descend to his aunts. The descent is the same if a man dies seised of lands in tail, except where the estate tail was limited to such man and the heirs of his body, for in that case the lands can only descend to those who are heirs of the body. In all cases where several females take one inheritance by descent, they are called parceners; and all lands or tenements, including a rent charge, may descend in this manner. If there be a title of dignity descendible to heirs of the body, the lands and tenements belonging to it may descend to parceners; but the dignity itself does not descend, for all the parceners only make one heir, and a title of dignity is not in its nature divisible. The dignity therefore will be in abeyance. [Baron.]

The descent of the crown is an exception to this rule; for if there are several daughters, &c., and no male heir, the crown with all its rights descends to the eldest female. In the case of the high constableship of England, if there were parceners, the office was executed by the husband of the eldest daughter, and, before her marriage, by deputy.

Parceners resemble joint tenants in having a unity of title and one entire freehold; but the unity of title can only be by descent, and there is no survivorship among parceners; if one of them dies, her heir is parcener with the survivor or survivors. Parceners resemble tenants in common, in having each a moiety or several interest in the land which has descended to them. It follows from the nature of this interest, that one parcener may either enfeoff another parcener of her share, or release her share to such parcener. If a parcener aliene her undivided share before partition, the alienee is tenant in common with the other parceners.

Parceners may voluntarily make partition of the land among them; or any one might formerly compel her coparceners to make such division by a writ entitled de partitione faciendâ, which was also applicable to the case of joint tenants and tenants in common. The Court of Chancery in course of time acquired a jurisdiction in these matters, and a bill may be filed in chancery by a parcener, praying for partition, which prayer will be granted on the parcener making out her title. The partition is effected by issuing a commission out of chancery to commissioners, who set out and divide the lands, upon which the parties execute mutual conveyances. When partition is made, the several parceners hold their lands as several and distinct estates. By statute 8 & 9 Vict., c. 106, a deed is made necessary to a partition. It might previously have been effected by a writing not under seal. The general Inclosure Act, 8 & 9 Vict., c. 118, contains a provision by which the Inclosure Commissioners are enabled to effect partitions in a more compendious mode than that of a suit in chancery. (2 Blackst. 'Comm.,' p. 320, Mr. Kerr's ed.)

Coparcenary may exist among males and females. For instance, if a man has two daughters, and one of them dies in his life-time, but leaving a son and daughters, and then the father dies, the son of the deceased daughter will be coparcener with his aunt; for he must trace his descent through his mother, who, if she had survived her father, would not have been his heir, but together with her sister, who did survive the father, would have made his heir.

By a recent Act (3 & 4 Will. IV., c. 27, s. 12) it is declared that when a parcener has been in possession of more than her share of the land, or in the receipt of more than her share of the rent, held in coparcenary, for her own benefit or for the benefit of some other persons than her coparceners, such possession or receipt by her shall not be considered the possession or receipt of her coparceners.

When all the sons take the land equally among them by descent, as in the case of gavelkind lands in Kent, they are parceners by custom.

Coparcenary is not very common at present, lands being generally so settled as to prevent its occurrence. The chief rules as to coparcenary are stated in Comyn's 'Digest,' 'Parcener;' and in Littleton, b. iii., "Of Parceners."

PARCHMENT is the skin of an animal prepared for writing upon. The name is a corruption of the Latin *Pergamena*, from Pergamus, the alleged place of its invention. Parchment is said to have been invented by Eumenes II., king of Pergamus (who reigned B.C. 197–159), in consequence of the prohibition of the export of papyrus from Egypt by Ptolemy Epiphanes; but parchment of at least 1000 years earlier date is in the collections of the British Museum. [Papyrus.] The probability is, that some improvement was made in the manufacture at Pergamus. The word Pergamena was not used until several centuries after the death of Eumenes. Tatto, a monk of the 4th century, is, according to Mabillon, the first writer in whose works it is met with. Previous to his time the usual term was *membrana*, which is the word we find in the Greek Testament, 2 Timothy, iv. 13.

The ancient parchment must have been exceedingly fine, if we are to believe the story of Cicero's having seen the 'Iliad' written on this material enclosed in a nut-shell; but for this we have only Pliny's authority. ('Hist. Nat.,' vii., c. 21.) The parchment of the 7th to the 10th century was white and good; and at the earliest of these periods it appears to have nearly superseded papyrus, which was brittle and more perishable. A very few books of the 7th century have leaves of parchment and papyrus mixed, that the former costly material might strengthen and support the friable paper. About the 11th century it grew worse. This may possibly have arisen from the circumstance, that writers of this time prepared their own parchment, and that they were probably not so skilful as manufacturers; and a dirty coloured parchment is evidence of a want of antiquity. A curious passage from a sermon of Hildebert, archbishop of Tours, who was born in 1054, is a voucher for this fact. The sermon is on the 'Book of Life,' which he recommends his hearers to obtain. "Do you know what a writer does? He first cleanses his parchment from the grease, and takes off the principal part of the dirt; then he entirely rubs off the hair and fibres with pumice-stone; if he did not do so, the letters written upon it would not be good, nor would they last long. He then rules lines, that the writing may be straight. All these things you ought to do, if you wish to possess the book which I have been displaying to you." (Sermon xv., Paris, 1708, fol.) At this time parchment was a very costly material; we find it mentioned that Gui, count of Nevers, having sent a valuable present of plate to the Chartreux of Paris, the unostentatious monks returned it with a request that he would send them parchment instead. It had long been customary to erase ancient writing from parchment by rubbing it with pumice-stone. When the custom began we do not know; but it had became common in the 9th and 10th centuries. [Palimpsest.] But the invention of linen paper came in aid to the uses of parchment; and when its manufacture became cheap, it superseded the more costly article for all purposes except those in which luxury was aimed at or uncommon durability required.

Parchment is ordinarily made of the skin of sheep or lambs. For drums it is often made of goat or wolf skins; the parchment with which church-books are covered is made of pigs' skins. Vellum is a finer, smoother, and whiter sort of parchment, made of the skins of very young calves.

Whatever may be the kind of skin used, the process of manufacturing is the same. When the skin is divested of its hair or wool, it is placed for some time in a lime-pit, and then stretched on a square wooden frame drawn tight by pegs. When in the frame, it is first scraped on the flesh side with a blunt iron, then wetted with a moist rag, covered with pounded chalk, and rubbed well with pumice-stone; after a short pause, these operations are repeated, but without chalk; the skin is then turned and scraped on the hair side once only; the flesh side is scraped once more, and again rubbed over with chalk, which must be brushed off with a piece of lamb-skin retaining the wool. All this is done by the skinner, who allows the skin to dry in the frame, and then cuts it out and sends it to the parchment-maker, who repeats the operations with a sharper tool, using a sack stuffed with flocks to lay the skin upon instead of stretching it in a frame. One of the largest pieces of parchment ever prepared forms part of a drum made by Mr. H. Distin for the Crystal Palace, and first used in June, 1860; it is 7 feet in diameter.

There is a kind of parchment made from refuse fish. The skin and offal being removed, all the rest is mixed with a dilute solution of soda ashes or carbonate of potash, and then with a dilute solution of muriatic acid. The mass is then pulped, washed over sieves to remove the bones, &c., drained or pressed, and saturated with a dilute solution of bichloride of mercury. When washed thoroughly, the pulp is formed into sheets in the same way as paper; and these sheets are finally rolled and pressed to equalise the surface. The sheets may either be used as parchment or may be tanned into a kind of leather.

PARCHMENT, VEGETABLE, is a substance lately brought into notice, as an important addition to the materials for manufactures. It is in fact, paper, but paper so altered as to possess many of the qualities of parchment. Messrs. Mongolfier, of Paris, have a mode of so preparing paper as to convert it into a kind of parchment, applicable, among other purposes, as a substitute for goldbeaters'-skin; but Mr. Gaine's vegetable parchment is a different substance. As described before the Royal Institution, in 1857, it appears to be paper altered in its textural qualities by the action of sulphuric acid. [Papyrin.] Very little more is required than dipping a sheet of paper into the acid; but then the strength of the acid must be exactly determined. The peculiar effects of acids and alkalies on paper were known long before—as in Kuhlmann's pyroxylised texture, Pelouze's gun paper, and Mercer's process for fibrous textiles; but Mr. Gaine's success depends mainly on the adoption of one particular strength of sulphuric acid, mixed with half its bulk of water. A sheet of paper being dipped in this liquid, it is almost instantly changed in character. It becomes tough, hard, and fibrous, without any alteration of weight. It gives a writing surface far better than that of animal parchment. It receives oils and varnishes freely. It bears rubbing better than any kind of paper, and almost as well as sheepskin. It will serve as a substitute for vellum in bookbinding; as a material for policies, certificates, &c.; as a strong paper for school-books: and as covering for jars and bottles of various kinds. Ordinary paper, even after being printed on, can be converted into this vegetable parchment. The substance is so strong, that a ring seven-eighths of an inch in width, and weighing only 23 grains, is said to bear a suspended weight of 92 lbs.

Soon after Mr. Gaine's process became known, and commercially introduced by Messrs. De la Rue, Mr. W. Crookes made experiments to determine its possible or practicable relation to photography. He passed slips of paper-photographs through acid of the required strength, and found that the colours and tints, even in the delicate half-tones, remained intact; that the uniform contraction of the paper added materially to the sharpness of the picture; that the paper became much stronger than before; that it would bear rough handling immediately, without tearing; that the non-albumenised photographs acquired a peculiar glossy appearance, giving a rich finish without glare; and that the picture might be washed with soap and water, and rubbed with a cloth, without injury.

Professor Muschamp, of Wurtemberg, has devised a mode of making paper waterproof, without, however, giving it those qualities which belong to vegetable parchment. He dissolves 24 ozs. of alum and 4 ozs. of white soap in 2 lbs. of water; also, 2 ozs. of gum arabic, and 6 ozs. of glue, in 2 lbs. of water; the two solutions are mixed, and the sheets of paper dipped into the mixture while warm. The sheets are hung up till dry, and sometimes also passed between rollers. The paper thus prepared is intended for packages exposed to the weather.

PARCLOSE, or PERCLOSE, an enclosure; in Gothic architecture the screen or railing which encloses anything, or separates it from the main body of the church. Thus the screen or railing which divides the choir from the nave; shuts off a mortuary chapel; or surrounds a tomb, is termed a parclose.

PARDON. According to the laws of most countries, a power of pardoning, or remitting the penal consequences of a conviction for crimes before the judicial tribunals, is vested in the chief magistrate of the state. The utility of such a power has been doubted by judicial writers, upon the ground that it supposes an imperfect system of criminal law, and that every instance of its exercise is the proclamation of an error either in the law itself or in the administration of justice. (Beccaria, chap. 46.) There is no doubt that the nearer a penal system approaches to perfection, the fewer will be the occasions for resorting to extrajudicial remissions of the execution of the law: but considering the numerous causes of erroneous decision, arising not only from the imperfection of laws themselves, but from the infinite sources of error in the instruments and means by which they are administered, it seems to be desirable that some power should exist which may by timely interference prevent the occurrence of irremediable wrong in cases where the error cannot be corrected by any appellate tribunal. At the same time it is evident that such a power should be circumscribed and defined, as far as its nature will admit, and exercised with the utmost caution. By the law of England, besides pardons by act of parliament, the power of granting pardons for crimes is exclusively vested in the sovereign as a branch of the prerogative. Prerogative.]

Formerly, Counts Palatine, Lords Marchers, and others who possessed *jura regalia*, had authority to pardon crimes; but by the stat. 27 Henry VIII., c. 24, this power was entirely abolished, and the sole right of remitting the sentence of the laws was permanently vested in the crown. The power of pardoning is applicable in all cases in which the crown is either concerned in interest or prosecutes for the public; the only exception being that contained in the Habeas Corpus Act (31 Car. II., c. 2, s. 12), by which persons convicted of signing commitments of British subjects to foreign prisons, are declared to incur the penalties of a *præmunire* and to be "incapable of any pardon from the crown."

The crown has, moreover, no power to pardon any offence in the prosecution of which a subject has a legal interest, or, as Bracton expresses it, "non potest rex gratiam facere cum injuriâ et damno aliorum" (lib. iii., p. 132). Thus in appeals of death, robbery, or rape, the king could not pardon the defendant, "because," says Sir Edward Coke, "it is the suit of the party to have revenge by death" (3 'Inst.' 237). Upon the same principle, where an attaint was brought against a jury who had delivered a false verdict, and the party in whose favour it had been given was joined in the attaint, the king might pardon the *jury*, if convicted, because they were merely subject to an exemplary punishment; but he could not pardon the *party*, because the latter was liable to make restitution to the plaintiff who prosecuted the attaint. So also in informations upon penal statutes, where the penalty or any part of it goes to the informer, or the party grieved, the crown cannot pardon the offender. Formerly, the crown appears to have exercised without restriction the power of pardoning offenders impeached by the Commons in parliament; but the lawfulness of the exercise of this power during the pendency of the proceedings was questioned by the House of Commons on the impeachment of the Earl of Danby in the reign of Charles II. (Howell's 'State Trials,' vol. ii., p. 724); and it was afterwards enacted, by the Act of Settlement, "that no pardon under the great seal of England shall be *pleadable* to an impeachment by the Commons in Parliament." This statute however does not affect the power of the crown to pardon the offender after he has been found guilty upon the impeachment, and the proceedings are determined.

A pardon from the crown to be effectual must apply in express terms to the particular offences intended to be pardoned; and no grant of a commission or protection by the king can amount by implication to a pardon of any offence previously committed.

A pardon may be either absolute or subject to any condition which the crown may think proper to annex to it; and in the latter case, the validity of the pardon will depend upon the performance of the condition. Until the recent improvements in the criminal law of England, almost all felonies were nominally capital; and in the numerous cases where it was not intended that the sentence of death should be executed, the criminal obtained a pardon upon condition of his submitting to transportation or some other punishment. At the present day, where the crown interferes to mitigate or commute a sentence, the mode by which it is effected is by granting a conditional pardon.

It was formerly necessary that a pardon should be under the great seal; but by stat. 7 & 8 Geo. IV., c. 28, s. 13, it is now sufficient, if under the sign manual, and countersigned by one of the secretaries of state.

The effect of a pardon is not merely to prevent the infliction of the punishment denounced by the sentence upon the offender, but to give him a new capacity, credit, and character. A man attainted of felony ceases to be *probus et legalis homo*, and can neither bring an action for damages nor be a witness or a juror in any legal proceeding; but upon receiving a pardon, all these legal disabilities are removed. In this respect a pardon by the law of England differs from the abolitio of the Roman law, to which in other points it bears a near resemblance. According to the latter, "Indulgentia, quos liberat, notat; nec infamiam criminis tollit, sed pœnæ gratiam facit." ('Cod.' lib. ix., tit. 43.) By the English law a distinction is made as to the effect of a pardon where the incapacity is part of the legal sentence, and not merely a consequence of attainder, as in the case of perjury under the statute 5 Elizabeth, c. 9; where the incapacity or infamy is part of a statutory sentence, a pardon from the crown has been held not to restore the party, and in such a case nothing less than an act of parliament will have that effect. Some doubt has been expressed, and the point has not yet received a judicial determination, whether a pardon will fully restore a person convicted of a crime, such as perjury, which is considered infamous at the common law. This subject is elaborately discussed, and all the authorities carefully examined in Mr. Hargrave's 'Argument on the Effect of the King's Pardon of Perjury.'

(Hargrave's *Juridical Arguments*, vol. ii., p. 221.)

PARELLIC ACID ($C_{18}H_6O_8$?), *Parellin*. One of the substances produced in the various dyeing lichens of commerce. It is found in company with lecanoric acid. [Lichens, *Colouring matters of.*]

PARELLIN. [Parellic Acid.]

PARENT AND CHILD. This relation arises only from a legal marriage. The relation between parents and their illegitimate children is considered in the article Bastard.

Parents are bound to maintain their legitimate children who are unable to maintain themselves owing to infancy or inability to work. This obligation extends to father and mother, grandfather and grandmother, if they are able to perform it (43 Eliz., c. 2; 5 Geo. I., c. 8). But such persons are only bound to furnish the children with the necessaries of life; and the penalty incurred in case of refusal is only 20*s*. per month. A husband is also, by 4 & 5 Will. IV., c. 76, liable to maintain the children of his wife, born before marriage, whether they are legitimate or not, until they are of the age of sixteen, or until the death of his wife. If a parent deserts his children, the churchwardens and overseers may seize his goods and chattels, and receive his rents, to the amount mentioned in the justices' warrant, which must be obtained before such seizure is made.

Formerly, if a Popish parent refused to allow his Protestant child a suitable maintenance, with the view of compelling him to come over to the Roman Catholic religion, the lord chancellor might enforce from the parent a proper allowance (11 & 12 Will. III., c. 4); and so if Jewish parents refused to allow their Protestant children a maintenance suitable to the parent's fortune and the age and education of the children, the lord chancellor might make such order as he thought proper (1 Anne, st. i. c. 30). Both statutes were repealed by 9 & 10 Vict., c. 59.

Parents are not bound to make any provision for their children after their death. Every man, and every woman who is capable of disposing of her property by will, may dispose of it as they please; except a freeman of London, who is under some limitations as to the power of disposing of his personalty by will, which limitations are in favour of his wife and children. A parent or child may aid each other in a law suit, without being guilty of maintenance. [Maintenance.]

Parents are not legally bound to give any education to their children, nor are they under any restrictions as to the kind of education they may give. Certain penalties might formerly be imposed (1 Jac. I., c. 4; 3 Jac. I., c. 5) on a person who sent a child under his government beyond seas, either to prevent his good education in England or for the purpose of placing him in a Popish college, or being instructed in the Popish religion. The statute 3 Car. I., c. 2, extended these penalties, and added certain disabilities. It seems that it was intended to repeal these penal and disabling statutes by the 31 Geo. III., c. 32, in favour of any Roman Catholic who took the oath therein prescribed. They are now repealed by 2 & 3 Will. IV. c. 115.

The power of a parent over his childen continues until the age of twenty-one, when they are emancipated; and if a parent die leaving a child under age, he may appoint a guardian to such child till the age of twenty-one. A mother has no power over her children.

A child under age may acquire property by gift; and if a father is the trustee of his child's estate, he must account to the child when he comes of age, like any other trustee. So long as a child who is under age lives with and is supported by the father, the father is entitled to receive the reward of the child's labour. When a child has a fortune of his own, and the father is not able to maintain him suitably to such fortune, a court of equity will allow the father a competent sum for maintenance out of the child's estate; but a father is not entitled to any such allowance in respect of costs incurred by him for his child's maintenance before he obtains such order of court for maintenance.

A parent may maintain an action for the seduction of a daughter on the ground of loss of her services, if there is evidence of her acting in the capacity of servant, or living with the parent in such a manner that the parent had a right to her services. This action has been maintained by a father in the case of his daughter, a married woman above age, living separate from her husband, and with the father; and by an aunt for the seduction of her niece living with her, to whom she stood in the relation of parent. The foundation of the right to maintain such an action is the loss of the services to which the parent is entitled.

A father is legally entitled to the care and custody of his children, but he may be deprived of the care of them by the court of chancery, if his conduct is such as, in the opinion of the court, endangers the morals of the children. Percy Bysshe Shelley was, among other things, restrained by an order of the court of chancery from taking possession of the persons of his infant children, on the ground of his professing irreligious and immoral principles and acting on them. W. P. T. L. Wellesley was also restrained by a like order from removing his children from the care and custody of their aunts, on the ground of his immoral conduct, and directions were given by the court for the custody and education of the children. But, except in such cases as these, the children cannot be taken from the care of the father and given into the custody of the mother or any other person.

Under Talfourd's act (2 & 3 Vict., c. 54) a mother may obtain access to her child which is in the sole custody of the father, or of any person by his authority, or of any guardian after the death of the father, subject to such regulations as the court of chancery may think convenient and just; and if such child shall be within the age of seven years, the court may order the child to be delivered into the custody of the mother until the child attains the age of seven years. But no mother is to have the benefit of the act against whom adultery has been established by judgment in an action at law, or by the sentence of an ecclesiastical court.

A child who is under the parental power owes obedience to his parent, which the parent may enforce by his superior strength, provided he uses it with moderation. He may beat his child and restrain his liberty, but not in such a way as to injure his health. A child is legally bound to maintain his indigent father and grandfather, mother and grandmother, if he is able; the penalty in case of refusal is 20*s.* per month.

The paternal power (patria potestas) among the Romans was a peculiar feature in their institutions. It was founded on a legal marriage, or on a legal adoption: the children of such marriage and such adopted children were in the power of the father; the mother had no power over them. It followed from the principle of the patria potestas, which involved a right of property, that the children of a son, not emancipated, were also in the power of their grandfather. By the death of the grandfather the son became *sui juris*, and his children and grandchildren fell into his power. This patria potestas could be dissolved by EMANCIPATION. Originally the father's power was absolute over the child, who had no independent political existence, at least as a member of his father's family. He was a Roman citizen, but at home he was subject to the domestic tribunal. Within the family the father had a power of life and death, and could sell the son as a res mancipi, either by way of punishment, or by way of dissolving the family connection. [EMANCIPATION.] The father also originally possessed the jus noxae dandi with respect to his son as well as a slave, a power which was a consequence of the principle of the father being answerable for the delicts of his son, and continued so long as that principle was in full vigour. The son who was in the power of his father could acquire no property for himself; all his acquisitions, like those of a slave, belonged to his father; but at the death of the father they might become his own property, a circumstance which distinguished the acquisitions of a son from those of a slave. The father could marry his children, divorce them, give them in adoption, and emancipate them at pleasure.

The strict notion of the patria potestas lies at the foundation of the Roman polity. Like other institutions, however, which in the early history of a state form its essential elements, the strict character of the patria potestas became gradually relaxed and greatly changed. The history of such changes is part of the history of Rome.

The patria potestas might be dissolved in other ways besides those mentioned. If a father or son lost his citizenship, the relation between them ceased, for this relationship could only exist between Roman citizens. If father or son was made a prisoner by an enemy, the relation was in abeyance (in suspenso), but was not extinct. If the son attained certain high offices in the state, either civil or religious, the patria potestas was thereupon dissolved.

(Gaius, i. 55, 97, 127, &c.; Marezoll, *Lehrbuch der Instit. des Röm. Rechtes*, 1839; Savigny, *System des heutigen Röm. Rechts*, 1840.)

PARGETING, or PARGE-WORK, the old English term for plasterwork in building. It is now chiefly applied to the ornamental plasterwork, mostly of patterns moulded in relief, of which characteristic examples are seen on the fronts of houses of the reigns of Elizabeth and James I., some of which are very picturesque. By workmen the term is used in the present day for the plastering of the sides of chimney-places and other coarse work.

PARHE'LION (*παρὰ*, by the side of, *ἥλιος*, the sun), a name given to the mock suns, as they have been called, which sometimes appear near the sun; being, as is supposed, images of the latter formed by reflection from a cloud.

PARIAN CHRONICLE is the name given to a block of marble preserved at Oxford, which contained in its perfect state a chronological account of the principal events in Greek history during a period of 1318 years, beginning with Cecrops, B.C. 1582, and ending with the archonship of Diognetus, at Athens, B.C. 264. The chronicle of the last ninety years was however lost, so that the part which now remains ends at the archonship of Diotimus, B.C. 354. This chronicle was purchased at Smyrna, together with several other relics of antiquity, by Mr. William Petty, who was employed by the Earl of Arundel, in the year 1624, for the purpose of making collections for him of ancient works of art in Greece, Asia Minor, and the islands of the Archipelago. Gassendi states in his 'Life of Peiresc' (lib. iv., ed. of 1629), who was counsellor in the parliament of Provence, and a munificent patron of arts and learning, that the Parian Chronicle was first discovered by means of Peiresc, and was purchased for him by one Sampson, his agent at Smyrna, for fifty pieces of gold, but that when it was ready to be sent on board, Sampson was thrown into prison, and that the Chronicle was afterwards purchased for Lord Arundel, by Mr. Petty, at a much higher price. Dr. Hales, in his 'Analysis of Chronology' (vol. i. p. 103, 8vo. edition), brings forward several reasons to show the improbability of this account; but however this may be, the Chronicle reached London in 1627, and was examined, at the suggestion of Sir Robert Cotton, with great care by the learned Selden, in conjunction with Patrick Young, librarian to James I. and Charles I., and Richard James, Fellow of Corpus Christi College, Oxford. "Many of the characters," says Selden, "were entirely obliterated, and many nearly so; nevertheless, by the assistance of glasses, and the critical sagacity of my very kind friend Patrick Young, after a great many repeated trials, I have restored them as well as I could." The Chronicle was published by Selden, together with other inscriptions which were brought to England by Mr. Petty in the following year (1628), under the title of 'Marmora Arundelliana.'

During the civil war in the reign of Charles I., the Earl of Arundel removed to Antwerp, and many of the marbles, which were deposited in the gardens of Arundel House, were defaced and broken, or used to repair the house. The latter was the fate of the Parian Chronicle; the upper part of it, containing at least half the inscription, is said to have been worked up in repairing a chimney at Arundel House; but fortunately a copy of it was preserved in Selden's work.

In 1667 the Hon. Henry Howard, grandson of the Earl of Arundel who obtained the Chronicle from Greece, presented it to the University of Oxford, where it is preserved, together with other antiquities collected by the Earl of Arundel, in a room adjoining to the public schools, called the Musæum Arundelianum. The Chronicle was published again in Prideaux's 'Marmora Oxoniensia,' fol. 1676, which was reprinted in 1732, under the care of Michael Maittaire, and again in 1791, Oxford, under the care of W. Roberts. In Chandler's 'Marmora Oxoniensia,' which was published in 1763, great pains were bestowed upon the Parian Chronicle, and many parts in which the inscription was defaced were supplied by conjectures, which are frequently very ingenious and probable. It has also been published, with an English translation, in the works of Robertson, Hewlett, and Hales, which are mentioned in the course of this article.

The authenticity and antiquity of this Chronicle was never called in question till the latter end of the last century, when a work was published by the Rev. J. Robertson under the title of 'The Parian Chronicle, or the Chronicle of the Arundelian Marbles, with a Dissertation concerning its Authenticity,' London, 1788, in which it is maintained to be a fabrication of modern times. The principal objections brought forward by Robertson are:—1. That the characters have no certain or unequivocal marks of antiquity. 2. It is not probable that the Chronicle was engraved for private use. 3. It does not appear to have been engraved by public authority. 4. The Greek and Roman writers for a long time after the date of this Chronicle complain that they had no chronological account of the affairs of ancient Greece. 5. This Chronicle is not once mentioned by any writer of antiquity. 6. Some of the facts seem to be taken from authors of a later date. 7. Parachronisms appear in some of the epochas, which we can hardly suppose a Greek chronologer in the 129th Olympiad would be likely to commit, &c.

The objections of Robertson were replied to by Mr. Hewlett, in a work entitled 'A Vindication of the Authenticity of the Parian Chronicle,' London, 1789: by Mr. Gough, in the ninth volume of the 'Archæologia;' and by Porson, in the 'Monthly Review,' in 1789. His objections have been more recently noticed in the first volume of Hales's 'Chronology;' and the whole subject has been investigated with great accuracy by Böckh, in the second volume of his 'Corpus Inscriptionum.' The authenticity of the Chronicle has been also vindicated by Wagner, Gött., 1790, 8vo. The result of these inquiries can leave little doubt respecting the authenticity and antiquity of the Chronicle; and the subsequent silence of classical writers respecting it, which is perhaps the strongest argument against its antiquity, may be accounted for, as Dr. Hales has remarked, by the retired and insular situation of Paros. It is written in pure and classical Greek; the characters bear several marks of antiquity; and none of the passages adduced by Robertson to prove that parts of it were taken from writers of a later date are sufficient to establish the fact.

The marble on which the Chronicle was engraved was five inches thick, and measured, when Selden viewed it, 3 feet 7 inches by 2 feet 7 inches; but one corner had been broken off. It contained at that time 93 lines, reckoning the imperfect ones, and might originally perhaps have contained a hundred. Upon an average the lines consist of 130 letters, all capitals, in close continuation, and unbroken into words. The events which it records are not so much those which relate to the history of the different states of Greece, but rather such as serve to illustrate the history of the civilisation and literature of

Greece. Thus we do not find one event in the Peloponnesian war either mentioned or alluded to, but we have an account of the establishment of the principal religious festivals, of the introduction of the different kinds of music into those festivals, of the origin of tragedy and comedy, and of the time in which the most eminent poets and philosophers lived.

For an examination of the dates which are assigned to the different events it records, the reader is referred to the first volume of Hales's 'Analysis of Chronology.'

PARIDIN ($C_{12}H_{10}O_6$?). A crystalline, colourless, organic substance found in the leaves of the *Paris quadrifolia*. It is coloured red by concentrated phosphoric or sulphuric acid.

PARIETIN. A name first given to a substance extracted from *Parmelia parietina*, but which has now been proved to be identical with usnic acid. [USNIC ACID.]

PARIGLIN. [SMILACIN.]

PARING AND BURNING. This operation consists in cutting a thin slice from the surface of land which is overgrown with grass, heath, fern, or any other plants which form a sward by the matting together of their roots. The sods are allowed to dry in the sun to a certain degree, after which they are arranged in heaps, and burnt slowly, without flame or violent heat. The result is a mixture of burnt earth, charred vegetable fibre, and the ashes of that part which is entirely consumed.

The object of this operation is twofold: first, to kill insects and destroy useless or noxious weeds completely; and secondly, to obtain a powerful manure, impregnated with alkaline salts and carbonaceous matter, which experience has shown to be a very powerful promoter of vegetation.

The instruments by which this is effected are, either a common plough with a very flat share, which may be used when the surface is very level without being encumbered with stones or large roots, as in low moist meadows, or in most other cases a paring-iron used by hand. Instead of the common plough, Snowden's or Woofe's paring plough (Hancock, Gloucester) may be used. It is a very effective tool—self-cleaning in its operation—and capable of cutting a thinner slice than can be separated by the common plough. The hand-parer is a most cumbrous tool, and in its use the power of the workman is most wastefully exerted. The crossbar of the instrument is held with both hands; and the upper parts of the thighs, being protected by two small slips of board, push the instrument into the ground, so as to cut a slice of the required thickness, which is then turned over by moving the cross-handle. The labour is severe, and a good workman can scarcely pare more than one-sixth of an acre in a day. The price of this work is from 15*s.* to 25*s.* per acre, according to the price of labour. The drying, burning, and spreading of the ashes are contracted for at from 10*s.* to 15*s.* more: thus the whole cost is from 25*s.* to 2*l.* per acre. In France it is done by a *cob*, which is like a shipwright's adze, and the operation is called *écobuer*.

Paring and burning the surface is an almost invariable preliminary in the converting of waste lands to tillage; and where these lands are in a state of nature, overrun with wild plants which cannot be easily brought to decay by simply burying them in the ground, burning is the readiest and most effectual mode of destroying them. In this case the practice is universally recommended and approved of.

But it is not only in the reclaiming of waste lands, and bringing them into cultivation, that paring and burning the surface is practised. The fertility produced by the ashes, which is proved by the luxuriance of the vegetation in the first crop, has induced many to repeat this process so often, as materially to exhaust the soil, and induce partial sterility. Hence the practice has been recommended on the one hand, and strongly reprobated on the other.

When we come to apply to the subject the test of experience, and reason correctly on the facts which are presented to us by the abettors of the practice and its adversaries, we shall find that the advantages and disadvantages arise chiefly from the circumstances under which the operation is carried on. But it may be necessary to an impartial examination of the subject, to inquire into the changes produced on the substances subjected to the process of burning, when it is done with due precautions.

In burning vegetable matter in an open fire, the whole of the carbon is converted into carbonic acid and flies off, leaving only some light ashes containing the earthy matter and the salts which the fire could not dissipate. These are no doubt very powerful agents in promoting vegetation, when they are added to any soil: but they are obtained at a very great expense of vegetable matter, which by its decomposition in the earth, might also have afforded food for vegetation. If the earth which is burnt with the sods is of a cold clayey nature, the fire will change it into a kind of sand, or brick dust, which is insoluble in water, and corrects the too great tenacity of clays, by converting them more or less into loams. This is so well known, that clay is often dug out of the subsoil to be partially burnt. But in addition to the many mechanical effects of heat on clay, there are certain chemical results of great advantage to fertility. When not burned to excess the alkaline ingredients of clays become more soluble when they are exposed to heat, and no doubt some of the beneficial effects of clay burning are due to the greater quantity of soluble alkaline matter which is then made available: and on stiff clay soils therefore there is a double advantage in paring and burning, that of the vegetable ashes and of the burnt clay.

Burning clay soils is in fact something analogous to liming. Lime dissolves the vegetable matter and sets free the alkalies, and it enables the detached elements to enter into new combinations; but if no new vegetable matter be added to restore what is exhausted by vegetation, liming, as well as paring and burning, is detrimental in the end. Many experienced farmers pare and burn the soil on the edges of their ditches and on the banks on which the hedges grow, because they thereby exterminate many rank weeds; and the burnt earth mixed with farm-yard dung makes an admirable compost. Here the burnt earth acts as an absorbent, and no doubt attracts many of the volatile parts of the manure, which are produced by the decomposition of animal and vegetable matter in it. Paring and burning therefore should be joined to manuring, if a powerful and immediate effect is desired without exhausting the soil; and in this case we do not hesitate to recommend it on all cold clay soils where rank weeds are apt to spring up, and coarse grasses take the place of the better sorts which have been sown. The proper time to pare and burn is evidently after the land has lain in grass for several years, and is broken up for tillage. The surface should be pared thin; about two inches is the extreme thickness allowable for the sod if the soil is very stiff and poor, and as thin as possible in a better soil. The sods should be moderately dried, and then arranged into small heaps with a hollow in the middle to hold heath or bushes to kindle the fire. When it has fairly established itself, all the apertures should be carefully closed. Wherever any fire breaks out, a fresh sod should be immediately put over it; a heap containing a small cart-load of sods should be smouldering for several days without going out, even if it rains hard. If the fire is too brisk, the earth will form hard lumps, and even vitrify; but otherwise it comes out in the form of a fine powder, in which evident marks of charcoal appear. If this is of a fine red colour, it is a good sign; for the iron in the earth has been converted into a peroxide, which is perfectly innocent in its effects on vegetation, whereas all the saline impregnations of iron are more or less hurtful. It is better to burn the sods in large than in small heaps; for the more the fire is smothered, the better the ashes.

So great a quantity of ashes is sometimes produced as to admit of a portion being carried off on grass-land, or used to manure another field for turnips. As this is evidently robbing the field where the operation has been carried on, an equivalent quantity of manure should be brought in exchange. Perhaps the most advantageous mode of using the ashes is to spread them in the drills where the turnip-seed is to be sown, after a portion of dung has been buried under them. In this manner the ashes from one acre of land pared and burnt, together with ten or twelve cart-loads of good yard dung, and a half dressing of superphosphate of lime, will manure two acres, and all the manure of one acre, in the ordinary mode of raising turnips on ridges, will be saved. If the ashes will produce as good turnips with half the usual quantity of dung, the expense of paring and burning is amply repaid. But experience proves that the earth and ashes almost ensure a good crop of turnips in many poor stiff soils in which they would probably not have succeeded if sown in the common course of cultivation without bones or ashes.

When a considerable extent of poor land is brought into cultivation, and there is no sufficient supply of manure at hand, paring and burning a portion of the land every year, by which a crop of turnips is obtained, is a most effectual means of improvement. Lime may be used at the same time with the ashes, and will increase their effect, provided some vegetable undecayed matter remains in the soil after paring; but lime will tend to exhaust this; and if, in consequence of liming, a few good crops of corn are obtained at first, the soil will be so exhausted as to be of little value afterwards. This is the abuse of the practice, which has caused it to come into disrepute. It would be a great waste to burn the surface of a rich piece of grass-land where the plants growing in it are tender and succulent, and would readily rot on being ploughed under; in such case a moderate application of lime would have a much better effect. This kind of land will produce good crops without any manure, and continue fertile for many years if judiciously cultivated. To pare and burn rich land is wasteful, and can never be recommended. It is only on poor land which has not strength to produce a crop, and of which the texture requires to be improved and its powers stimulated, that paring and burning is advantageous; on poor thin chalky soils which have been laid down with sainfoin, of which the roots and stems are grown coarse and hard, so as not readily to rot in the ground, the operation is proper and advantageous. The turnips produced by the ashes, with or without the assistance of dung, must be fed off by sheep folded on the land, whose dung and urine will enrich it, and their tread consolidate it. By this mode of proceeding great advantages are obtained from paring and burning, and the land, so far from being deteriorated, will be improved.

Many landlords rigidly forbid their tenants to pare and burn any part of their land, from an idea that the heart of it is destroyed by the burning. But in the hands of an intelligent tenant the practice is perfectly safe and even beneficial, for he knows it to be his interest to apply a certain quantity of dung, either at the same time that the land is thus treated, or for the next crop, and where under ordinary farming there is no sowing of corn crops except after turnips, clover, or some other green crop consumed on the farm, there could be little danger of any detriment to the land, even if it were pared and burnt once in every ten or twelve years, provided it were judiciously treated in the intervals. The farmer would be benefited in many situations, and the practice would tend to keep up the value of the farms.

In Devonshire, where the land has been pared and burnt from time immemorial, even where the soil is rich, the practice has been often resorted to without any judgment. Provided a crop of corn or potatoes was obtained at little cost, the consequences to the future state of the land were not heeded; and landlords, seeing their farms impoverished, put a stop to the practice. Thus many useful modes of cultivation have been reprobated from the abuse of them, which, properly applied, would have been advantageous to all parties. There is no maxim more true than this: that whatever injures the landlord, injures the farmer who is not desirous of removing, and *vice versâ;* and all positive restrictions on cultivation, however necessary when there is a fear of dishonest conduct, diminish the value of a farm and lessen the rent which can be fairly afforded for it. Ignorance is often a greater destroyer of the interest of both landlord and tenant than wilful dishonesty; and the spreading of useful information amongst tenants, so that they may see their own advantage, is the surest means of improving landed property. Many tracts of waste land might be brought into cultivation by means of paring and burning, which without it would never repay the labour required. Where the soil is inclined to peat, this operation and abundant liming are the indispensable preliminaries of cultivation. The ashes and the lime will produce vegetation and food for animals. These will produce dung to supply what the vegetation abstracts, and to assist also in the further decomposition of the peaty matter, converting it into vegetable mould.

The first crop after paring and burning, as was observed before, should, if possible, be turnips, and these should be consumed on the spot; but there are exceptions to the rule. The soil may be a stiff clay of a considerable degree of natural fertility, only encumbered with rank weeds and grasses. In this case the surface is burnt to destroy these, and a crop of corn may safely be taken after the paring and burning, the land coming into a regular alternate rotation after it. For example, the next crop may be beans or tares, with a good proportion of dung; or clover may be sown with the first crop, if the ground appears fit for it. The effect of the ashes will be readily perceived in the luxuriance of the clover. Such land may be afterwards cultivated, according to its nature and quality, with the rest of the farm; or laid down to grass after a course of cleansing and ameliorating crops. Thus old wet meadows, after having been well underdrained, may be greatly improved, and either converted into arable fields or laid down again with choice grasses.

Old rough pastures have often been greatly improved by a very thin paring and burning, so as not to destroy all the roots of the grass. When the ashes are spread over the pared surface, some good grass-seeds are sown with them. The whole is well harrowed or scarified and rolled, and the grass which will spring up after this will be greatly improved, and will fully repay the expense of this simple mode of renovating it. This is the cheapest mode of improving coarse pastures that we know, without breaking them up.

The partial paring and burning of the headlands of fields, for the purpose of mixing the ashes and burnt earth with dung in a compost, is a most excellent practice, and often superior to that of using the sods only, without burning them. These sods contain innumerable seeds of weeds, and eggs or maggots of insects, which are not destroyed by the fermentation of the heap, but on the contrary, are brought to life. The loss of a portion of vegetable matter in the burning is amply compensated by the destruction of these enemies of the future crops.

It now only remains to take notice of the soils and situations where paring and burning cannot be recommended. Wherever the soil is very loose from a great proportion of silicious sand in its composition, and is held together chiefly by the slender roots which run through it, the burning would destroy the whole of the vegetable matter; and the residue would be a mere barren silicious sand, much worse and more porous than it was when held together by the roots. The only way to bring such soils into cultivation is to put clay or marl on them, and to force vegetation by means of liquid and other manures, consolidating them by every means applicable, so that they may retain moisture, and that the manure may not be washed through by the rains. Such soils may be improved, but they are the most ungrateful of any; and it is only necessity and indefatigable industry which can make them produce any crops.

On the whole, the operation of paring and burning, when judiciously applied and properly performed, is a most excellent and cheap improvement of dry soils, and it will never diminish their fertility, if they are properly cultivated and manured, and a judicious succession of crops is adopted; but on the contrary it will improve their quality and texture, and make them more productive.

PARIS RED. [Colouring Matters.]

PARIS YELLOW. [Colouring Matters.]

PARISH. This word is probably derived into the English language from the French *paroisse,* and the Latin *parochia* or *paroecia,* and ultimately from the Greek *paroikia* (παροικία). At the present day it denotes a circumscribed territory, varying in extent and population, but annexed to a single church, whose incumbent or minister is entitled by law to the tithes and spiritual offerings within the territory. In the early ages of Christianity the term appears to have been used in some parts of Europe to signify the district or diocese of a bishop, as distinguished from the 'provincia' of the archbishop or metropolitan. (Du Cange, 'Gloss.,' ad verb. 'Parochia;' Selden's 'History of Tithes,' chap. vi., sect. 3.) These large ecclesiastical provinces were gradually broken down into subdivisions, for which ministers were appointed, either permanently or occasionally, who were under the rule of the bishop, were paid out of the common treasury of the bishopric, and had no particular interest in the oblations or profits of the church to which their ministry applied. This was the state of things in the primitive times, which probably continued till towards the end of the 3rd century. After that period proprietors of lands began, with the licence of the higher ecclesiastical authorities, to build and endow churches in their own possessions; and in such cases the chaplain or priest was not paid by the bishop, but was permitted to receive for his maintenance and to the particular use of his own church the profits or the proportion of the profits of the lands with which the founder had endowed it, as well as the offerings of such as repaired thither for divine service. This appears to be a probable account of the origin and gradual formation of parochial divisions in almost all countries where Christianity prevailed; and Selden has satisfactorily shown that the history of parishes in England has followed the same course. Soon after the first introduction of Christianity into this country, the heathen temples and other buildings were converted into churches or places of assembly, to which the inhabitants of the surrounding district came to receive religious instruction from the minister, and to exercise the rites of Christian worship. As the members of the new religion increased, a single or occasional minister was insufficient for the purpose; and a bishop, with subordinate priests, began to reside in the immediate neighbourhood of the religious houses, having the charge of districts of various extent, comprehending several towns and villages, and assigned principally with a view to the convenience of the inhabitants in assembling together at the church. Within these districts, or *circuits,* as they were called, which were precisely analogous to the diocesan *parishes* in other parts of Europe, the ministering priests itinerated for the purpose of exercising their *shriving,* but they always resided with the bishop. By degrees other churches were built to meet the demands for public worship, but still at first wholly depending upon the mother-church, and supplied by the bishop from his family of clergy resident at the bishopric with ministers or curates, who were supported by the common stock of the diocese. For the fund or endowment in each of these districts was common; and whatsoever was received from tithes or the offerings of devotees at the different altars, or by any other means given for religious uses, was made into a general treasure or stock for the ecclesiastical purposes of the whole diocese; and was applied by the bishop in the first place to the maintenance of himself and the college of priests resident with him at the church, and afterwards for distribution in alms among the poor and for the reparation of churches.

This community of residence and interest between the bishop and his attending clergy, who are often termed in the chronicles of those days *episcopi clerus,* constituted the notion of cathedral churches and monasteries in their simplest form. How long this state of things continued does not precisely appear, though Selden expresses an opinion that it was in existence as late as the 8th century. ('History of Tithes,' chap. ix., sect. 2.) It has indeed been asserted by Camden ('Britannia,' p. 160), and was formerly the commonly received opinion, that Honorius, the first archbishop of Canterbury after Augustine, divided his province into parishes about the year 630; but Selden proves satisfactorily that Honorius could not have made a parochial division in the sense in which we now understand the term; and that, if made at all, it must have been such a distribution into districts, then called parishes, as is above described, and which was so far from originating with Honorius, that it must have been nearly as ancient as bishoprics.

It seems most probable that the creation of parishes in England was not a simultaneous act, but was the gradual result of circumstances, and was not fully effected till near the time of the Conquest. (Hallam's 'Middle Ages,' vol. ii., c. 7, pt. 1.) As Christianity became the universal religion, and as population increased, the means of divine worship supplied by the bishoprics and monasteries became inadequate to the wants of society, and lords of manors began to build upon their own demesnes churches and oratories for the religious purposes of their families and tenants. Each founder assigned a definite district, within which the functions of the minister officiating at his church were to be exercised, and expressly limited the burden as well as the advantages of his ministry to the inhabitants of that district. As these acts of piety tended to the advancement of religion, and were in aid of the common treasury of the diocese, they were encouraged by the bishops, who readily consecrated the places of worship so established, and consented that the minister or incumbent should be resident at his church, and receive for his maintenance, and for the use of that particular church, the tithes and offerings of the inhabitants, as well as any endowment or salary which the founder annexed to it. This endowment or salary usually consisted of a glebe, or a portion of land appropriated to that purpose, which was indeed the only means of providing for the maintenance of the incumbent at a time when almost all the wants of life were supplied from the immediate produce of the earth, and, together with the right of receiving the other ecclesiastical profits which arose within the territory limited by the founder, became the settled revenue of the church, and annexed to it in perpetuity. The last concession made to the lay founder was probably the patronage or right of presenting the clerk to the church, which by the primitive constitution, belonged exclusively to the bishop; and when this was obtained, these limited territories differed in no material respect from our modern parishes. Indeed it can scarcely admit of doubt that our parochial divisions arose chiefly from these lay-foundations, the differences in extent being accounted for by the varying limits appointed for them at their origin. Their names were derived from some favourite saint, from the site, or the lordship to which they belonged, or from the mere fancy of the respective founders. Such appears to have been the origin of the lay parishes; and it is reasonable to conclude that as soon as this practice was established, the bishops and religious houses, in the districts or parishes in which they had reserved to themselves the right of presentation, followed the same course by limiting the ecclesiastical profits of each church to the particular incumbent, and restricting the devotions as well as the offerings of the inhabitants to that church only.

The earliest notice of these lay foundations of parishes is by Bede, about the year 700 ('Hist. Eccl.' lib. v., c. 4 and 5). By the end of the 8th century they had become frequent, as clearly appears from the charters of confirmation made to Croyland Abbey, by Bertulph, king of Mercia, in which several churches of lay-foundation are comprehended. In the laws of king Edgar (A.D. 970) there is an express provision that every man shall pay his tithes to the most ancient church or monastery where he hears God's service; "Which I understand not otherwise," says Selden, "than any church or monastery whither usually, in respect of his commorancy or his parish, he repaired: that is, his parish church or monastery." ('History of Tithes,' chap. ix., 1-4.)

Although the origin of parishes generally in England is pretty clearly ascertained, the history of the formation of particular parishes is almost wholly unknown. As these divisions originated in an unlettered period, and were too local and obscure to be recorded in the chronicles or general histories of the times, and for the most part too ancient to be preserved in any episcopal registers now existing, it would be unreasonable to expect any satisfactory evidence of their particular origin; and as a matter of fact, no evidence whatever can be produced on the subject.

However satisfactory this account of the origin of parishes may be with reference to country parishes, it furnishes no explanation of the origin of parishes in towns—a subject which is involved in great obscurity; and indeed the changes which the latter may be shown to have undergone within time of memory seem to point to a different principle of formation.

The country parishes appear to be nearly the same in name and number at the present time as they were at the time of Pope Nicholas's 'Taxation,' compiled in the reign of Edward I. (A.D. 1288); but in some of the large towns the number of parishes has very considerably decreased. Thus, in the city of London there are at present 108 parishes, though at the time of the 'Taxation' the number was 140; in like manner in Norwich the number has been reduced from 70 in the time of Edward I., to 37 at the present day. In other ancient towns, such as Bristol, York, and Exeter, the number does not appear to have materially changed, but the names have been often altered. The particular causes of these variations it would be difficult to trace; but greater changes might reasonably be expected in towns than in the country parishes, in consequence of more frequent fluctuations of wealth and population in the former. Where a decrease has taken place in the number of town parishes in the three last centuries, it is probably to be accounted for by the great reduction since the Reformation in the amount of oblations and what are called *personal* tithes, which in cities were almost the only provision for the parochial clergy.

The size of English parishes varies much in different districts. In the northern counties they are extremely large, forty square miles being no unusual area for a parish; and, generally speaking, parishes in the north are said to average seven or eight times the area of those in the southern counties. The boundaries of parishes in former times appear to have been often ill-defined and uncertain; but since the establishment of a compulsory provision for the poor by means of assessments of the inhabitants of parishes, the limits have in general been ascertained with sufficient precision.

It is not easy to ascertain the exact number of parishes in England and Wales; for although they have been enumerated on several occasions, the number ascertained has usually depended upon the object and purpose of the particular enumeration. Thus in the returns under the Poor Law Commission, a parish is generally considered as a place or district supporting its own poor, and from these returns, in 1854, it appears that the total number of such places is 14,603, and the number is constantly increasing with the increase of population. But in this number are included many subdivisions of parishes, such as the townships in the northern counties, which by stat. 13 & 14 Car. II., c. 12, f. 21, are permitted to maintain their own poor, and also other places which by act of parliament, though not parishes, have the same privilege. Another difficulty, which has probably affected all the enumerations which have hitherto been made, is the large number of doubtful parishes. It is somewhat uncertain at the present day what circumstances constitute a parish church. In the Saxon times, and for some centuries after the Conquest, the characteristics which distinguished a parish church from what were called field churches, oratories, and chapels, were the rights of baptism and sepulture. (Selden, 'History of Tithes,' chap. ix., 4; Degge's 'Parsons' Counsellor,' part i., chap. xii.) But in modern times this line of distinction would include as parish churches almost all chapels-of-ease, and also the churches and parochial chapels erected under the stat. 58 Geo. III., c. 45, "for building additional churches in populous places." The various views entertained of the constituents of a parish will in a great measure account for the different results of the several enumerations which have been made; and this is in fact one of the reasons assigned by Camden for the difference between the number of the parish churches in England and Wales stated to Henry VIII. in 1520, by Cardinal Wolsey, and that stated about a century after to James I., the former being 9407, and the latter 9284. (Camden's 'Britannia,' 161-2.) The number of the parishes mentioned in Pope Nicholas's 'Taxation' above referred to, as nearly as can be ascertained, appears to be between these two accounts. Blackstone says, that the number of parishes in England and Wales had been computed at 10,000. Perhaps the number of parishes in England and Wales (meaning by the term simply a district annexed to a church whose incumbent is by law entitled to tithes in that district) may be taken to be about 11,000.

(See Holland's 'Observations on the Origin of Parishes,' in Hearne's *Discourses*, vol. i. p. 194; and Whitaker's *History of Whalley*, book ii. chap. I.)

PARK. This term, in its legal signification as a privileged enclosure for beasts of the forest and chace, is at the present day nearly obsolete. Under the ancient forest-laws, the franchise of the highest degree was that of a forest which was *nomen generalissimum*, and contained within it the franchises of chace, park, and warren. The only distinction between a chace and a park was, that the latter was enclosed, whereas a chace was always open, and they both differed from a forest, inasmuch as they had no peculiar courts or judicial officers, nor any particular laws, being subject to the general laws of the forest; or as Sir Edward Coke maintains, to the common law exclusive of the forest-laws. (4 'Inst.,' 314.) A chace and a park differed from a forest also in the nature of the wild animals to the protection of which each was applied. The beasts of the forest, or beasts of venery, as they were called, were *tantùm silvestres*, that is, as Manwood explains the phrase ('Forest Laws,' chap. iv., sec. 4), animals such as the hart, hind, hare, boar, and wolf, which "do keep the coverts, and haunt the woods more than the plains." On the other hand, the beasts of chace or park were *tantùm campestres*, that is to say, they haunted the plains more than the woods. According to the strict legal meaning of the term, no subject can set up a park without the grant of the Crown or immemorial prescription, which is presumptive evidence of such a grant. In modern times the term is little known, except in its popular acceptation as an ornamental enclosure for the real or ostensible purpose of keeping fallow deer, interspersed with wood and pasture for their protection and support. (Blackst. 'Comm.' Mr. Kerr's ed. vol. ii.)

PARK OF ARTILLERY. [ARTILLERY PARK.]

PARK, ENGINEER, is the term applied to the whole equipment of stores, intrenching tools, &c. belonging to the engineer department in the field, and to the depôt where these are stored, and where the officers and men of this branch of the service are camped. In a siege the engineer park should be as near as possible to the siege works, but covered from the enemy's fire. Natural positions, in hollows and behind hills, affording such protection, may generally be found within 1000 yards or so of the first parallel.

PARKS, PUBLIC. [ARBORETUM.]

PARLIAMENT, IMPERIAL, the legislature of the United Kingdom of Great Britain and Ireland, consisting of the king or queen [KING], the lords spiritual and temporal [LORDS, HOUSE OF], and the knights, citizens, and burgesses [COMMONS, HOUSE OF] in parliament assembled.

The word is generally considered to be derived from the French *parler*, to speak. "It was first applied," says Blackstone, "to general assemblies of the states under Louis VII. in France about the middle of the 12th century." The earliest mention of it in the statutes is in the preamble to the statute of Westminster, A.D. 1272.

ORIGIN AND ANTIQUITY OF PARLIAMENT.

The origin of any ancient institution must be difficult to trace, when in the course of time it has undergone great changes; and few subjects have afforded to antiquaries more cause for learned research and ingenious conjecture than the growth of our parliament into the form which it had assumed when authentic records of its existence and constitution are to be found. Great councils of the nation existed in England both under the Saxons and Normans, and appear to have been common amongst all the nations of the north of Europe. They were called by the Saxons *michel-synoth*, or great council; *michel-gemote*, or great meeting; and *wittena-gemote*, meeting of wise men—by the last of which they are now most familiarly known.

The constitution of these councils cannot be known with any certainty, and there has been much controversy on the subject, and especially as to the share of authority enjoyed by the people. Different periods have been assigned for their admittance into the legislature. Coke, Spelman, Camden, and Prynne agree that the commons formed part of the great synods or councils before the Conquest; but how they were summoned, and what degree of power they possessed, is a matter of doubt and obscurity. "The main constitution of parliament, as it now stands," says Blackstone, "was marked out as long ago as the seventeenth year of King John, A.D. 1215, in the great charter granted by that prince, wherein he promises to summon all archbishops, bishops, abbots, earls, and greater barons [BARONS] personally, and all other tenants in chief under the crown by the sheriff and bailiffs, to meet at a certain place, with forty days' notice, to assess aids and scutages when necessary; and this constitution has subsisted, in fact at least, from the year 1266, 49 Hen. III., there being still extant writs of that date, issued by Simon de Montfort, earl of Leicester, to summon knights, citizens, and burgesses to parliament." A statute, also, passed 15 Edw. II. (1322), declares that "the matters to be established for the estate of the king and of his heirs, and for the estate of the realm and of the people, should be treated, accorded, and established in parliament, by the king and by the assent of the prelates, earls, and barons, and the commonwealth of the realm, *according as had been before accustomed.*" In reference to this statute, Mr. Hallam observes, "that it not only establishes by a legislative declaration the present constitution of parliament, but recognises it as already standing upon a custom of some length of time." (1 'Const. Hist.,' 5.)

CONSTITUENT PARTS OF PARLIAMENT.

These have been treated of in separate articles, and nothing more will be attempted in this place than a brief analysis, which will bring the whole under one view. Of the king (or queen), the first in rank, nothing need be repeated.

The House of Lords is at present composed of—

LORDS SPIRITUAL.

2 archbishops (York and Canterbury)
24 English bishops
4 Irish representative bishops

Total, 30

LORDS TEMPORAL.

3 princes of the blood royal
20 dukes
21 marquesses
111 earls
22 viscounts
213 barons
16 representative peers of Scotland
28 representative peers of Ireland

Total, 461

The number has been greatly augmented from time to time, and there is no limitation of the power of the crown to add to it by further creations. The titles of all temporal peers are now hereditary; since the decision of the House of Lords in 1856 (when by letters patent Baron Wensleydale was created "for and during his natural life"), that neither such letters patent, nor the writ of summons, could enable the person named therein to sit or vote in parliament. The introduction of the representative peers of Scotland and Ireland was effected on the union of those kingdoms respectively with England. The former are elected by the hereditary peers of Scotland descended from Scottish peers at the time of the Union, and sit for one parliament only; the latter are chosen for life by the peers of Ireland, whether hereditary or created since the Union. The power of the crown to create Irish peers is limited by the Act of Union, so that one only can be created when three of the peerages of Ireland have become extinct.

The House of Commons properly consists of 658 members, but St. Albans and Sudbury having been disfranchised, and not having been replaced by any other towns, it now consists of 654 only, distributed as follows:—

ENGLAND AND WALES.

159 knights of shires
337 citizens and burgesses

Total, 496

SCOTLAND.

30 knights of shires
23 citizens and burgesses

Total, 53

IRELAND.

64 knights of shires
41 citizens and burgesses

Total, 105

Total of the United Kingdom, 654.

An account of the changes effected in the parliamentary constituencies at different times, more particularly by the Reform Act, and a full view of the present system of representation, is given in the article COMMONS, HOUSE OF.

The lords and commons originally were one assembly, but the date of their separation is not known. Sir Edward Coke states that he had seen a record, 30 Hen. I. (1130), of their degrees and seats as one body, and affirms that the separation took place at the desire of the commons. (13 'State Trials,' 1410.) Elsynge avers that "the commons ever had a place for their consultation apart from the lords, though they did often meet and sit together in one room," and gives several precedents in support of his position. ('Manner of Holding Parliaments,' pp. 101–104, 155.)

POWER AND JURISDICTION OF PARLIAMENT.

1. LEGISLATIVE AUTHORITY COLLECTIVELY.—The authority of parliament extends over the United Kingdom and all its colonies and foreign possessions. There are no other limits to its power of making laws for the whole empire than those which are common to it and to all other sovereign authority, the willingness of the people to obey, or their power to resist them. It has power to alter the constitution of the country, for that is the constitution which the last act of parliament has made. It may take away life by acts of attainder, and make an alien be as a natural-born subject.

Parliament does not in the ordinary course legislate directly for the colonies. For some, the queen in council legislates, and others have legislatures of their own, and propound laws for their internal government, subject to the approval of the queen in council; but these may afterwards be repealed or amended by direct statutes from this country. Their legislatures and their laws are both subordinate to the mother country.

The power of imposing taxes upon colonies for the support of the parent state was attempted to be exercised by parliament upon the provinces of North America; but this attempt was the immediate occasion of the severance of that great country from our own. The injustice and hardship of colonial taxation must be admitted; but the legal power of parliament to impose such taxes can only be restrained by its own acts conferring constitutions and privileges upon the colonies, which are all subject to its authority.

There are some subjects indeed upon which parliament, in familiar language, is said to have no right to legislate; such for instance as the Church; but no one can intend more by that expression than that it is inexpedient to make laws as to such matters. The very prayers and services of the Church are prescribed by statute. Parliament has changed the professed religion of the country, and has altered the hereditary succession to the throne. To conclude, in the words of Sir Edward Coke, the power of parliament "is so transcendent and absolute, that it cannot be confined, either for causes or persons, within any bounds."

2. DISTRIBUTION OF POWERS BETWEEN KING, LORDS, AND COMMONS.—Custom and convenience have assigned to different branches of the legislature peculiar powers. These are subject to any limitation or even transference which parliament may think fit. The king swears at the coronation to govern "according to the statutes in parliament agreed upon," and these of course may be altered. Prerogatives of the crown which have ever been enjoyed might yet be taken away by the king, with the consent of the three estates of the realm. The king sends and receives ambassadors, enters into treaties with foreign powers, and declares war or peace, without the concurrence of lords and commons; but these things he cannot do without the advice of his ministers, who are responsible to parliament. Without entering into a view of his general prerogatives, which are treated of elsewhere [KING], it will be necessary to advert to certain parliamentary functions exercised by him, and which are most important in the conduct of legislation.

Summons.—It is by the act of the king alone that parliament can be assembled. There have been only two instances in which the lords and commons have met of their own authority, namely, previously to the restoration of King Charles II. and at the Revolution in 1688.

The first act of Charles II.'s reign declared the lords and commons to be the two houses of parliament, notwithstanding the irregular manner in which they had been assembled, and all their acts were confirmed by the succeeding parliament summoned by the king; which however qualified the confirmation of them by declaring that "the manner of the assembling, enforced by the difficulties and exigencies which then lay upon the nation, is not to be drawn into example." In the same manner the first act of the reign of William and Mary declared the convention of lords and commons to be the two houses of parliament, as if they had been summoned according to the usual form, and the succeeding parliament recognised the legality of their acts. But although the king may determine the period for calling parliaments, his prerogative is restrained within certain limits; as he is bound by statute to issue writs within three years after the determination of any parliament; while the practice of providing money for the public service by annual enactments renders it compulsory upon him to meet parliament every year.

There is one contingency upon which the parliament may meet without summons, under the authority of an Act of parliament. It was provided by the 6 Anne, c. 7, that "in case there should be no parliament in being at the time of the demise of the crown, then the last preceding parliament should immediate convene and sit at Westminster, as if the said parliament had never been dissolved." By the 37 Geo. III., c. 127, a parliament so revived would only continue in existence for six months, if not sooner dissolved.

As the king appoints the time and place of meeting, so also at the commencement of every session he declares to both houses the cause of summons by a speech delivered to them in the House of Lords by himself in person, or by commissioners appointed by him. Until he has done this, neither house can proceed with any business.

The causes of summons declared do not make it necessary for parliament to consider them only, or to proceed at once to the consideration of any of them. After the speech, any business may be commenced; and the commons, in order to prove their right to act without reference to any authority but their own, invariably read a bill a first time *pro formâ* before they take the speech into consideration. Other business is also done very frequently at the same time. New writs are issued for places which have become vacant during the recess, returns are ordered, and even addresses are presented on matters unconnected with the speech.

Prorogation and Adjournment.—Parliament, it has been seen, can only commence its deliberations at the time appointed by the king; neither can it continue them any longer than he pleases. He may prorogue parliament by having his command signified in his presence by the lord-chancellor or speaker of the House of Lords to both houses, or by writ under the great seal, or by commission. The effect of a prorogation is at once to suspend all business until parliament may be summoned again. Not only are the sittings of parliament at an end, but all proceedings pending at the time, except impeachments by the commons, are quashed. A bill must be renewed after a prorogation, as if it had never been introduced, though the prorogation be for no more than a day. William III. prorogued parliament from the 21st October, 1689, to the 23rd, in order to renew the Bill of Rights, concerning which a difference had arisen between the two houses that was fatal to it. It being a rule that a bill cannot be passed in either house twice in the same session, a prorogation has been resorted to in other cases to enable a second bill to be brought in.

Adjournment is solely in the power of each house respectively. It has not been uncommon indeed for the king's pleasure to be signified, by message or proclamation, that both houses should adjourn. Either of them however may decline complying with what can be considered as no more than a request. Business has frequently been transacted after the king's desire has been made known, and the question for adjournment put in the ordinary manner.

Dissolution.—The king may also put an end to the existence of parliament by a dissolution. He is not however entirely free to define the duration of a parliament, for after seven years it ceases to exist under the statute of George I., commonly known as the Septennial Act. Before the Triennial Act, 6 Wm. & Mary, there was no limit to the continuance of parliament, except the will of the king. Parliament is dissolved by proclamation, after having been prorogued to a certain day. This practice, according to Hatsell, "which has now been uniform for above a century, has probably arisen from those motives that are suggested by Charles I., in his speech in 1628, 'that it should be a general maxim with kings themselves only to execute pleasing things, and to avoid appearing personally in matters that may seem harsh and disagreeable.'"

In addition to these several powers of calling a parliament, appointing its meeting, directing the commencement of its proceedings, determining them for an indefinite time by prorogation, and finally of dissolving it altogether, the crown has the creation of one entire branch of the legislature; together with other parliamentary powers, which will hereafter be noticed in treating of the functions of the two houses.

The judicial functions of the lords and their right to pass bills affecting the peerage which the commons may not amend, are the only properties peculiar to them, apart from their personal rights and privileges.

Taxation.—The chief powers vested in the House of Commons are those of imposing taxes and voting money for the public service. Bills for these purposes can only originate in that house, and the Lords may not make any alterations in them, except for the correction of clerical errors. On the opening of parliament, the king directs estimates to be laid before the house, but the amount may be varied by the commons at pleasure. Grants distinct from those proposed in the estimates cannot be made without the king's recommendation being signified. The commons will not allow the right of the lords to insert in a bill any pecuniary penalties or to alter the amount or application of any penalty imposed by themselves; but the rigid assertion of this rule was found to be attended with much inconvenience, and a standing order was made in 1831, directing the Speaker in each case to report whether the object of the lords appears to be "to impose, vary, or take away any pecuniary charge or burthen on the subject," or "only to relate to the punishment of offences, and the house shall determine whether it may be expedient in such particular case to insist upon the exercise of their privilege."

On May 21, 1860, the bill for the repeal of the paper duty was thrown out by the House of Lords, after having been passed by the commons. This excited much attention, as it was contended that the power of refusing to repeal a tax was in fact equal to that of imposing one. It was, however, generally agreed that the lords had the power of refusing to pass any bill of which they disapproved. On July 5, the House of Commons, on the motion of Lord Palmerston, unanimously resolved, "1. That the right of granting aids and supplies to the crown is in the commons alone, as an essential part of their constitution; and the limitation of all such grants, as to the matter, manner, measure, and time, is only in them. 2. That although the lords have exercised the power of rejecting bills of several descriptions relating to taxation, by negativing the whole, yet the exercise of that power by them has not been frequent, and is justly regarded by this house with peculiar jealousy, as affecting the rights of the commons to grant the supplies and to provide the ways and means for the service of the year. 3. That to guard for the future against an undue exercise of that power by the Lords, and to secure to the commons their rightful control over taxation and supply, this house has in its own hands the power so to impose and remit taxes, and to frame bills of supply, that the right of the commons as to the matter, manner, measure, and time, may be maintained inviolate."

Right of determining Elections.—Another important power peculiar to the commons is that of determining all matters touching the election of their own members, and involving therein the rights of the electors. Upon the latter portion of this right a memorable contest arose between the Lords and Commons in 1704. Ashby, a burgess of Aylesbury, brought an action at common law against the returning-officers of that town for having refused to permit him to give his vote at an election. A verdict was obtained by him, but a judgment was given against him in the Queen's Bench, which was reversed by the House of Lords upon a writ of error. The commons declared that "the determination of the right of election of members to serve in parliament is the proper business of the House of Commons, which they would always be very jealous of, and this jurisdiction of theirs is uncontested; that they exercise a great power in that matter, for they oblige the officer to alter his return according to their judgment; and that they cannot judge of the right of election without determining the right of the electors, and if electors were at liberty to prosecute suits touching their right of giving voices in other courts, there might be different voices in other courts, which would make confusion, and be dishonourable to the House of Commons; and therefore such an action was a breach of privilege." In addition to the ordinary exercise of their jurisdiction as regarded the right of elections, the commons relied upon an Act of the 7 Will. III., c. 7, by which it had been declared, that "the last determination of the House of Commons concerning the right of elections is to be pursued." On the other hand, it was objected that "there is a great difference between the right of the electors and the right of the elected: the one is a temporary right to a place in parliament *pro hâc vice*; the other is a freehold or franchise. Who has a right to sit in the House of Commons, may be properly cognizable there; but who has a right to choose, is a matter originally established, even before there is a parliament. A man has a right to his freehold by the common law, and the law having annexed his right of voting to his freehold, it is of the nature of his freehold, and must depend upon it. The same law that gives him his right must defend it for him, and any other power that will pretend to take away his right of voting, may as well pretend to take away the freehold upon which it depends." These extracts from the Report of a Lords' Committee, 27th March, 1704, upon the conferences and other proceedings in the case of Ashby and White, give an epitome of the main arguments upon which each party in the contest relied. The whole of this Report, together with another of the 13th March, may be read with great interest.

Encouraged by the decision of the House of Lords, five other burgesses of Aylesbury, now familiarly known as "the Aylesbury men," commenced actions against the constables of their town, and were committed to Newgate by the House of Commons for a contempt of their jurisdiction. They endeavoured to obtain their discharge on writs of *habeas corpus*, but did not succeed. The commons declared their counsel, agents, and solicitors guilty of a breach of privilege, and committed them also. Resolutions condemning these proceedings were passed by the lords; conferences were held, and addresses presented to the queen. At length the queen came down and prorogued parliament, and thus put an end to the contest and to the imprisonment of the Aylesbury men and their counsel.

The question which was agitated at that time has never since arisen. The commons have continued to exercise the sole right of determining whether electors have had the right to vote while inquiring into the conflicting claims of candidates for seats in parliament, and specific modes for trying the right of election by the house have been prescribed by statutes, and its determination declared to be "final and conclusive in all subsequent elections, and to all intents and purposes whatsoever."

Connected with the right of the commons to adjudicate upon all matters relating to elections, may be mentioned their power over the eligibility of candidates. John Wilkes was expelled, in 1764, for being the author of a seditious libel. In the next parliament (February 3, 1769) he was again expelled for another libel; a new writ was ordered for the county of Middlesex, which he represented, and he was re-elected without a contest; upon which it was resolved, on the 17th of February, "that having been in this session of parliament expelled this house, he was and is incapable of being elected a member to serve in this present parliament." The election was declared void, but Mr. Wilkes was again elected, and his election was once more declared void, and another writ issued. A new expedient was now tried. Mr. Luttrell, then a member, accepted the Chiltern Hundreds, and stood against Mr. Wilkes at the election, and, being defeated, petitioned the house against the return of his opponent. The house resolved that although a majority of the electors had voted for Mr. Wilkes, Mr. Luttrell ought to have been returned, and they amended the return accordingly. Against this proceeding the electors of Middlesex presented a petition, without effect, as the house declared that Mr. Luttrell was duly elected. The whole of these proceedings were severely condemned, and on the 3rd of May, 1782, the resolution of the 17th of February, 1769, was ordered to be expunged from the journals as "subversive of the rights of the whole body of electors of this kingdom." A resolution similar to that expunged had been passed in the case of the unfortunate Hall, in 1580, as part of the many punishments inflicted upon him, which we shall have occasion to mention.

Oaths.—The power of administering oaths exercised by the lords is not claimed by the House of Commons. They formerly endeavoured to attain the end supposed to be secured by the administration of an oath, by resorting to the authority of justices of the peace who happened to be members of their own body; but all such expedients have long since been abandoned, and witnesses guilty of falsehood are punished by the house for a breach of privilege, not being amenable to the laws regarding perjury. Election committees have power by statute to administer oaths, and witnesses giving false evidence are guilty of perjury.

3. *Privileges.*—Both houses of parliament possess various rights and privileges for the maintenance of their collective authority, and for the protection, convenience, and dignity of individual members. At the commencement of each parliament, the Speaker, on behalf of the commons, has "laid claim to them of the king" since the reign of Henry VIII., but they appear to have been always enjoyed with equal certainty before that time. Some of them have been subsequently confirmed, modified, and even abolished by acts of parliament, but the petition of the Speaker remains unchanged, and prays for some which have been disallowed by law since the original form was adopted.

Commitment and Fines.—The power of commitment for contempt has always been exercised by both houses. It has been repeatedly brought under the cognisance of the courts, and allowed without question. Mr. Wynn, in his 'Argument,' states that there are upwards of one thousand cases of commitment by the House of Commons to be found in their Journals since 1547. Breaches of privilege committed in one session may be punished by commitment in another, as in the well-known case of Murray, in 1751-2, who was imprisoned in Newgate for a libel until the end of the session, and on the next meeting of parliament was again ordered to be committed; but he had absconded in the meanwhile. Contempts of a former parliament may also be punished. The lords may commit for a definite period beyond the duration of the session of parliament; but a commitment by the commons holds good only until the close of the session.

The House of Lords, in addition to the power of commitment, may impose fines. This privilege is not exercised by the commons, although there is a case in D'Ewes's 'Journal of Queen Elizabeth,' in which Mr. Hall, a member who had incurred their displeasure, by publishing a work "very slanderous and derogatory to the general authority, power, and state of the house, and prejudicial to the validity of its proceedings in making and establishing laws," was ordered to "pay a fine to the queen of five hundred marks." The house at the same time assumed a power not found to have been exercised in other cases. It committed Mr. Hall to the Tower, and ordered that he should remain there for "six months, and until he should made retraction of the book." This punishment was commitment for a time certain without reference to the continuance of the session, and, in the event of a refusal to retract the book, amounted to perpetual imprisonment. A practice still exists which partakes of the nature of a fine. There are certain fees payable by persons committed to the custody of the serjeant-at-arms, and it is usual on discharging them out of custody to attach the condition of the "payment of the fees." These fees are occasionally remitted under particular circumstances—in one case, on account of the poverty of the prisoner.

Freedom of Speech.—Freedom of speech is one of the privileges claimed by the Speaker on behalf of the commons, but it has long since been confirmed as the right of both houses of parliament by statutes. It was acknowledged by an act in the reign of Henry VIII., by which the proceedings of the stannary court with respect to Richard Strode, a member, who was fined and imprisoned by that court for having proposed a bill to regulate the tinners in Cornwall, were declared illegal, and the repetition of similar encroachments upon the privilege of parliament provided against. The language however was thought ambiguous, and it was by limiting its operation to the case of Strode, that a judgment was obtained in the King's Bench against Sir John Elliot, Denzil Hollis, and Valentine, in the reign of Charles I. A true interpretation of the law was subsequently established by resolutions of both houses of parliament, and by a formal reversal of this judgment by the house of lords. The most solemn recognition of the privilege is contained in the Bill of Rights, which declares "that the freedom of speech and debates and proceedings in parliament ought not to be impeached or questioned in any court or place out of parliament."

There are however certain legal incidents to this privilege, which it is necessary to notice. The law presumes that everything said in parliament is with the view to the public good and necessary for the conduct of public business; but should the member publish his speech, he is viewed as an author only, and if it contain libellous matter, he will not be protected by the privilege of parliament. In 1795, an information was filed against Lord Abingdon for libel. His lordship had accused his attorney, in parliament, of improper conduct in his profession. He afterwards published his speech in several newspapers at his own expense. His lordship pleaded his own cause, and contended that he had a right to print what he had, by the law of parliament, a right to speak; but Lord Kenyon said, "that a member of parliament had certainly a right to publish his speech, but that speech should not be made a vehicle of slander against any individual; if it was, it was a libel." In 1813, a much stronger case of the same kind occurred. Mr. Creevey, a member, had made a charge against an individual in the House of Commons, and incorrect reports of his speech having appeared in several newspapers, Mr. Creevey sent a correct report to an editor, requesting him to publish it in his newspaper. A jury found Mr. Creevey guilty of libel, and the court of King's Bench refused an application for a new trial; on which occasion Lord Ellenborough said, "a member of that house has spoken what he thought material and what he was at liberty to speak, in his character as a member of that house. So far he is privileged: but he has not stopped there; but, unauthorised by the house, has chosen to publish an account of that speech in what he has pleased to call a corrected form, and in that publication has thrown out reflections injurious to the character of an individual."

Freedom from Arrest.—The Speaker's petition prays on behalf of the commons, "that their persons, *their estates, and servants*, may be free from arrests and all molestations." These words are not more extensive than the privilege as formerly enjoyed, and instances in which it has been enforced may be found in nearly every page of the earlier volumes of the Journals. This privilege has however been limited by statutes, the last of which (10 Geo. III., c. 50) states in the preamble that the previous laws were insufficient to obviate the inconveniences arising from the delay of suits by reason of privilege of parliament, and enacts that "any person may at any time commence and prosecute any action or suit, &c., against any peer or lord of parliament, or against any of the knights, citizens, or burgesses for the time being, or against any of their menial or any other servants, or any other person entitled to the privilege of parliament, and no such action shall be impeached, stayed, or delayed by or under colour or pretence of any privilege of parliament." Obedience to any rule of the courts at Westminster may be enforced by distress infinite, in case any person entitled to the benefit of such rule shall choose to proceed in that way.

The persons of members are still free from arrest or imprisonment in civil actions, but their property is as liable to the legal claims of all other persons as that of any private individual. Their servants do not enjoy any privilege or immunity whatever.

The privilege of freedom from arrest has always been subject to the exception of cases of "treason, felony, and surety of the peace;" and though in other criminal charges each house may, if it see fit, prevent the abstraction of a member from his parliamentary duties, the case of Lord Cochrane, in 1815, will show how little protection the House of Commons extends to its members in such cases. Lord Cochrane, having been indicted and convicted for a conspiracy, was committed to the King's Bench prison. He afterwards escaped, and was arrested by the marshal while sitting on the privy counsellor's bench in the House of Commons, on the right hand of the chair, at which time there was no member present, prayers not having been read. The committee of privileges declared that by this proceeding of the marshal of the King's Bench "the privileges of parliament did not appear to have been violated so as to call for the interposition of the house."

Courts of justice have committed privileged persons for contempt, and parliament has refused to protect them. By a standing order of the House of Lords, 8th June, 1757, it was declared "that no peer or lord of parliament hath privilege of peerage or of parliament against being compelled by process of the courts of Westminster-hall to pay obedience to a writ of habeas corpus directed to him;" and in the case of Earl Ferrers, it was decided that an attachment may be granted if a peer refuses obedience to the writ of habeas corpus. There have been two more recent cases, that of Mr. Long Wellesley in 1831, and that of Mr. Lechmere Charlton in 1837, in which members committed by the

Lord-Chancellor for contempt have laid claims to privilege, which were not admitted by the House of Commons.

Peers are always free from arrest; and as regards the commons, their privilege is supposed to exist for 40 days after every prorogation, and 40 days before the next appointed meeting.

Jurisdiction of Courts of Law in Matters of Privilege.—In connection with the exercise of privilege, an important point of law arises as to the jurisdiction of courts of justice. Each house of parliament is acknowledged to be the judge of its own privileges. Sir Edward Coke affirms, "whatever matter arises concerning either house of parliament, ought to be examined, discussed, and adjudged in that house to which it relates, and not elsewhere." (4 'Inst.') But again, in the disputes in the case of the Aylesbury men, which has been already referred to, the lords communicated to the commons at a conference a resolution "that neither house of parliament have power by any vote or declaration to create to themselves new privileges not warranted by the known laws and customs of parliament," which was assented to by the commons. (14 'Commons' Journals,' 555, 560.) The degree of jurisdiction to be exercised by the courts, and the proper mode of dealing with actions involving matters of privilege, it would indeed be difficult to determine, after the inconsistencies which have been shown in practice and the great variety of opinions expressed by learned men. No more than a concise statement of a few cases will be needed to show the difficulties in which the question is involved.

First, as to the right of courts to inquire into the existence and nature of privileges claimed by either house of parliament. Coke lays it down that "judges ought not to give any opinion of a matter of parliament, because it is not to be decided by the common laws, but *secundum leges et consuetudinem parliamenti;* and so the judges in divers parliaments have confessed." (4 'Inst.,' 15.) When Paty, one of the Aylesbury men, was brought before the Queen's Bench on a writ of habeas corpus, Mr. Justice Powell said "this court may judge of privilege, but not contrary to the judgment of the House of Commons:" and again, "this court judges of privilege only incidentally: for when an action is brought in this court, it must be given one way or other." (2 Lord Raymond, 1105.) The opinions of other judges to the same effect, expressed at different times, might also be given. The words contained in the Bill of Rights, that the "debate and *proceedings* in parliament ought not to be impeached or questioned in any court or place out of parliament," are generally relied upon in confirmation of this doctrine. If this view were always taken of the question, little difference between parliament and the courts of law would arise. The course would be simple. Whatever action might be brought would be determined in a manner agreeable to the house whose privileges were questioned; and if the lords, in case of appeal, were to abide by the same rule, there would be no dissensions. But as such unanimity of opinion has not always existed, there has been a clashing of jurisdictions which nothing probably but a statute can prevent for the future.

A judgment was obtained against Sir W. Williams, the Speaker of the House of Commons, in the second year of James II., for having caused a paper entitled 'Dangerfield's Narrative' to be printed by order of the house. This the house declared to be "an illegal judgment," and against the freedom of parliament. A bill was also brought in to reverse the judgment, but it miscarried in three different sessions. (10 'Commons' Journals,' 177, 205.)

The denial of the exclusive jurisdiction claimed by the commons in 1704, in respect of the right of elections, as stated above, is another important occasion in which the privilege of the commons has clashed with the judgments of legal tribunals.

The only other case which need be mentioned in this place is that of Stockdale *v.* Hansard. In this case an action was brought against the printers for a libel published in the papers printed by the order of the house. The litigation was long and intricate. The house passed certain resolutions, declaring that no court of law had power to decide as to their privileges, but the courts did not hold themselves bound by resolutions only. At length a bill was brought in and passed, by which proceedings, criminal or civil, against persons for publication of papers printed by order of either house of parliament, are to be stayed by the courts, upon delivery of the certificate and affidavit to the effect that such publication is by order of parliament.

Forms of Procedure.

Meeting of Parliament: Preliminary Proceedings.—On the meeting of a new parliament it is the practice for the lord chancellor, with other peers appointed by commission under the great seal for that purpose, to open the parliament by stating "that her Majesty will, as soon as the members of both houses shall be sworn, declare the causes of her calling this parliament; and it being necessary a Speaker of the House of Commons should be first chosen, that you, gentlemen of the House of Commons, repair to the place where you are to sit, and there proceed to the appointment of some proper person to be your Speaker; and that you present such person whom you shall so choose here to-morrow (at an hour stated) for her Majesty's royal approbation." The commons then proceed at once to the election of their Speaker. If any debate arises, the clerk at the table acts as Speaker, and standing up, points to the members as they rise. He also puts the question. When the Speaker is chosen, his proposer and seconder conduct him to the chair, where, standing on the upper step, he thanks the house and takes his seat. It is usual for some members to congratulate him when he has taken the chair. As yet he is only Speaker elect, and as such presents himself on the following day, in the House of Lords, and acquaints the lords commissioners that the choice of the commons has "fallen upon him," that he feels the difficulties of his high and arduous office, and that, "if it should be her Majesty's pleasure to disapprove of this choice, her Majesty's faithful commons will at once select some other member of their house better qualified to fill the station than himself." It is stated by Hatsell, that there have been only two instances "in which neither this form, of having the royal permission to proceed to the election of a Speaker, nor the other, of the king's approbation of the person elected, have been observed. The first is the election of Sir Harbottle Grimstone, on the 25th of April, 1660, to be Speaker of the Convention Parliament which met at the Restoration; the other, is the election of Mr. Powle, 22nd January, 1688-9, in the Convention Parliament at the Revolution." The only instance of the royal approbation being refused is in the case of Sir Edward Seymour, in 1678. Sir John Topham indeed was chosen Speaker in 1450, but his excuse was admitted by the king, and another was chosen by the commons in his place. In order to avoid a similar proceeding on the part of the king, Sir Edward Seymour, who knew that it had been determined to accept his excuse, omitted the usual form.

When the Speaker has been approved, he lays claim on behalf of the commons, "by humble petition, to all their ancient and undoubted rights and privileges," which being confirmed, the Speaker with the commons retires from the bar of the House of Lords.

Both houses then proceed to take the oaths required by law. In the commons the Speaker takes them before any other member. Three or four days are usually occupied in this duty before the sovereign declares to both houses, in person or by commission, the causes of calling the parliament. From this time business proceeds regularly. The first thing usually done in both houses is to vote an address in answer to the speech from the throne.

Before any business is undertaken, prayers are read; in the House of Lords by a bishop, and in the Commons by their chaplain.

Conduct of Business, Divisions, &c.—In the House of Lords business may proceed when three peers are present. In the House of Commons forty members are required to assist in the deliberations. If that number be not present at four o'clock in the afternoon, or if notice be taken, or if it appear on a division that less than that number are present, the Speaker adjourns the house until the next sitting day; but at the morning sittings, which are held on Wednesday for private business, petitions, &c., twenty members are sufficient, and they sit from twelve at noon till six, unless previously adjourned. Towards the end of a session morning sittings are held on other days. The house then meets at twelve, and precisely at six the Speaker adjourns the house, without putting the question, and the business in hand stands as orders of the day for the next sitting. Except on Wednesday or Saturday, on which days there is generally no evening sitting, after the adjournment the house resumes at six o'clock. In both houses all questions are decided by a majority, and none may vote but those present in the house when the question is put, though in the lords proxies are counted if held by a lord who is present. When any question arises upon which a difference of opinion is expressed, it becomes necessary to ascertain the numbers on each side. In the lords, the party in favour of the question are called "content," and that opposed to it, "non-content." In the commons these parties are described as the "ayes" and "noes." When the Speaker cannot decide by the voices which party has the majority, or when his decision is disputed, a division takes place. This is effected now (since 1836 in the commons and 1857 in the lords) by one party being sent to each of the two lobbies attached to either house. All within the house when the question is put must vote. Two clerks are stationed at each of the entrances to the house, holding lists of the members in alphabetical order printed upon large sheets of thick pasteboard so as to avoid the trouble and delay of turning over pages. While the members are passing into the house again, the clerks place a mark against each of their names, and the tellers count the number. This plan has been quite successful; the names are taken down with great accuracy, and very little delay is occasioned by the process.

In committees of the whole house, divisions are taken by the members of each party crossing over to the opposite side of the house, unless five members require that the names shall be noted in the usual manner.

In addition to the power of expressing assent or dissent by a vote, peers may record their opinion and the grounds of it by a "protest," which is entered in the Journals, together with the names of all the peers who concur in it.

When matters of great interest are to be debated in the upper house, the lords are "summoned;" and in the House of Commons an order is occasionally made that the house be called over, and members not attending when their names are called, are reported as defaulters, and ordered to attend on another day, when, if they are still absent and no excuse be offered, they are sometimes committed to the custody of the serjeant-at-arms.

The business which occupies nearly the whole attention of both houses (if we except the hearing of appeals by the lords and the trial of controverted elections by the commons) is the passing of bills; and the mode of proceeding with respect to them may be briefly described in the first place.

Bills, Public and Private.

Bills are divided into two classes—such as are of a public nature affecting the general interests of the state, and such as relate only to local or private matters. The former are introduced directly by the motions of members; the latter are brought in upon petitions from the parties interested, after the necessary notices have been given and all forms required by the standing orders have been complied with.

With few exceptions, public bills may originate in either house, unless they be for granting supplies of any kind, or involve directly or indirectly the levying or appropriation of any tax or fine upon the people. The exclusive right of the commons to deal with all legislation of this nature affects very extensively the practice of introducing private bills into either house. Thus, all those which authorise the levying of local tolls or rates are brought in upon petition to the lower house. These compose by far the greater part of all private bills. All measures of local improvement, whether for enclosing lands, lighting, watching, and improving towns, establishing police, or making roads, bridges, railways, canals, or other public works, originate in the commons; though in the session of 1860, in consequence of the pressure of business, many bills of this kind were first introduced in the House of Lords. On the other hand, many bills of a personal nature are always sent down from the lords, such as bills affecting private estates, divorce bills, and bills for the naturalisation of aliens. Bills affecting the peerage must originate in the lords, and acts of grace with the crown, where the prerogative of mercy is vested.

Progress of Bills: Public Bills.—Motions for leave to bring in bills of a public nature are not very frequently refused. The more usual time for opposing any measure in its progress is on the second reading, when all the provisions are known, and the general principle and effect of them may be considered. When leave is given to bring in a bill, certain members are ordered to prepare it, being the proposer and seconder of the motion, to whom others are sometimes added. It is then brought in and read a first time, and a day is fixed for the second reading, which generally leaves a sufficient interval for the printing and circulation of the bill.

It has been already said that the second reading is the occasion on which a bill is more particularly canvassed. Its principle is at that time made the subject of discussion, and if it meet with approval, the bill is committed, either to a committee of the whole house or to a select committee, to consider its several provisions in detail. A committee of the whole house is in fact the house itself, in the absence of the Speaker from the chair; but the rule which allows members to speak as often as they think fit, instead of restricting them to a single speech, as at other times, affords great facilities for the careful examination and full discussion of details. The practice of referring bills of an intricate and technical description to select committees has become very prevalent of late years, and might be extended with advantage. Many bills are understood by a few members only, whose observations are listened to with impatience, and thus valuable suggestions are often withheld in the house, which in a committee might be embodied in the bill. By leaving such bills to a select committee, the house is enabled to attend to measures more generally interesting, while other business, of perhaps equal importance, is proceeding at the same time; and it has always the opportunity of revising amendments introduced by the committee.

Before a bill goes into committee there are certain blanks for dates, amount of penalties, &c., which are filled up in this stage. Bills of importance are often recommitted, or in other words, pass twice, and even in some instances three or four times through the committee. When the proceedings in committee are terminated, the bill is reported with the amendments to the house, on which occasion they are agreed to, amended, or disagreed to, as the case may be. If many amendments have been made, it is a common and very useful practice to reprint the bill before the report is taken into consideration. After the report has been agreed to, the bill with the amendments is ordered to be engrossed previous to the third reading. A proposition was made not long since, but without success, for discontinuing the custom of engrossment upon parchment, and for using an examined copy of the printed bill, signed by the clerk of the house, for all the purposes for which the engrossed copy is now required.

The third reading is a stage of great importance, on which the entire measure is reviewed, and the house determines whether, after the amendments that have been made on previous stages, it is fit on the whole to pass and become law. The question, "that this bill do pass," which immediately succeeds the third reading, is usually no more than a form, but there have been occasions on which that question has been opposed, and even negatived. The title of the bill is settled last of all.

An interval of some days usually elapses between each of the principal stages of a bill; but when there is any particular cause for haste, and there is no opposition, these delays are dispensed with, and the bill is allowed to pass through several stages, and occasionally through all, on the same day.

This statement of the progress of bills applies equally to both houses of parliament. There is, however, a slight distinction in the title of a bill while pending in the lords, which is always "intituled an act," whether it has originated in the lords or has been brought up from the commons.

When the commons have passed a bill, they send it to the lords by one of their own members, who is usually accompanied by others. The lords send down bills by two masters in chancery; unless they relate to the crown or the royal family, in which case they are generally sent by two judges.

Private Bills.—In deliberating upon private bills parliament may be considered as acting judicially. The conflicting interests of private parties, the rights of individuals, and the protection of the public, have to be reconciled. Care must be taken, in furthering an apparently useful object, that injustice be not done to individuals, although the public may derive advantage from it. Vigilance and caution should be exercised lest parties professing to have the public interests in view should be establishing, under the protection of a statute, an injurious monopoly. The rights of landowners amongst themselves, and of the poor, must be scrutinised in passing an enclosure bill. Every description of interest is affected by the making of a railway.

The inquiries that are necessary to be conducted in order to determine upon the merits of private bills are too extensive for the house to undertake, and it has therefore been usual to delegate them to committees. To prevent parties from being taken by surprise, the standing orders require certain notices to be given (to the public by advertisement, and to parties interested by personal service) of the intention to petition parliament. The first thing which is done on receiving the petition therefore, is to inquire whether these notices have been properly given, and if all other forms prescribed by the standing orders have been observed. This inquiry is confided to the examiners of private bills, two officers who act for both houses, who report their determination to the house. When a private bill has been read a second time, it is commmitted, according to its character, to the committee of selection, to the general committee on railway and canal bills, or to the select committee on divorce bills. The committee of selection consists of the chairman of the standing orders committee and five other members nominated by the house, of whom three are a quorum. This committee classifies the bills, and nominates the chairman and members of the committee for each. The railway and divorce committees proceed in the like manner. For every opposed railway, canal, or road bill, the committee consists of five members not interested in the bill in progress. Unopposed bills are referred to the chairman of the committee of ways and means and two other members. The committees on opposed bills may hear counsel and examine witnesses,—divisions amongst the committee are decided by a majority, and the result of their labours is reported to the house.

Public bills are occasionally referred to select committees; these, however, must also pass through a committee of the whole house.

It will not be necessary to pursue any further the progress of private bills, which differs only from that already described in respect of bills of a public nature, in the necessity for certain specified intervals between each stage, and for notices in the private bill office.

In the House of Lords, when a private bill is unopposed, it is committed to the permanent chairman of committees, and any other peers may attend; but when a bill is to be opposed, the committee on standing orders inquires whether the standing orders have been complied with, and if so, the bill is referred to a committee of five, and a similar course is followed to that of the lower house.

In order to ensure a proper acquaintance with the provisions of private bills, some of which are very voluminous, the House of Commons have adopted a rule requiring breviates of the bills to be laid before them six days before the second reading, and breviates of the amendments made by the committee, before the house take the report into consideration.

Conferences between the two Houses.—The progress of bills in each house of parliament having been detailed, it still remains to describe the subsequent proceedings in case of difference between them. When a bill has been returned by either house to the other, with amendments which are disagreed to, a conference is desired by the house which disagrees to the amendments, to acquaint the other with reasons for such disagreement; in order, to use the words of Hatsell, "that after considering those reasons, the house may be induced, either not to insist upon their amendments, or may, in their turn, assign such arguments for having made them, as may prevail upon the other house to agree to them. If the house which amend the bill are not satisfied and convinced by the reasons urged for disagreeing to the amendments, but persevere in insisting upon their amendments, the form is to desire another conference; at which, in their turn, they state their arguments in favour of the amendments, and the reasons why they cannot depart from them; and if, after such second conference, the house resolve to insist upon disagreeing to the amendments, they ought then to demand a 'free conference,' at which the arguments on both sides may be more amply and freely discussed. If this measure should prove ineffectual, and if, after several free conferences, neither house can be induced to depart from the point they originally insisted upon, nothing further can be done, and the bill must be lost."

Whether the conference be desired by the lords or by the commons, the former have the sole right of appointing the time and place of meeting. The house that seeks the conference must clearly express in their message the subject upon which it is desired, and it is not granted as a matter of course. There are many instances to be found in the Journals in which a conference has been refused, but not of late years. The reasons that are to be offered to the other house are prepared by a committee appointed for that purpose, who report them for the approval of the house. These reasons are generally very short, but in some cases arguments have been entered into at considerable length. The conference is conducted by "managers" for both houses, who, on the part of the house desiring the conference, are the members of the committee who have drawn up the reasons, to whom others are occasionally added. Their duty is to read and deliver in the reasons with which they are entrusted to the managers of the other house, who report them to the house which they represent. At a free conference the managers on either side have more discretion vested in them, and may urge whatever arguments they think fit. A debate arose in a free conference, which was held in 1836, in reference to amendments made by the lords to a bill for amending the Act for regulating Municipal Corporations, and the speeches of the managers were taken in short-hand and printed. While the conference is being held, the business of both houses is suspended until the return of the managers.

Amendments made to bills by either house are not the only occasions upon which conferences are demanded. Resolutions of importance, in which the concurrence of the other house is desired, are communicated in this manner. Reports of committees have also been communicated by means of a conference. In 1829 a conference was demanded by the commons to request an explanation of the circumstances under which a bill that had been amended by the lords had received the royal assent without being returned to the commons for their concurrence. The lords expressed their regret at the mistake, and stated that they had themselves been prepared to desire a conference upon the subject, when they received the message from the commons.

Conferences were formerly held in the Painted Chamber, but since the rebuilding of the Houses of Parliament after the fire in 1834, they have been held in one of the lords' committee rooms.

Royal Assent to Bills has been described under Assent, Royal.

Committees.—Committees are either "of the whole house," or "select." The former are, in fact, the house itself, with a chairman instead of the Lord Chancellor or Speaker presiding. There is a more free and unlimited power of debate when the house is in committee, as members may speak any number of times upon the same question, from which they are restrained on other occasions. Select committees are specially appointed, generally for inquiring into particular subjects connected with legislation. It is usual to give them the "power to send for persons, papers, and records;" but in case of any disobedience to their orders, they have no direct means of enforcing compliance, but must report the circumstance to the house, which will immediately interfere.

In case of an equality of voices, the chairman, who is chosen by the committee out of its own members, gives the casting vote. Some misconception appears to have existed as to the precise nature of the chairman's right of voting. In 1836, the House of Commons was informed that the chairman of a select committee had first claimed the privilege to vote as a member of the committee, and afterwards, when the voices were equal, of giving a casting vote as chairman, and that such practice had of late years prevailed in some select committees; when it was declared by the house that, according to the established rules of parliament, the chairman of a select committee can only vote when there is an equality of voices. (91 'Commons' Journals,' p. 214.) This error was very probably occasioned by the practice of election committees, which was however confined to them, and only existed under the provisions of Acts of parliament.

In 1837 some regulations were made by the House of Commons for rendering select committees more efficient and responsible. The number of members on a committee was limited to fifteen. Lists of their names are to be fixed in some conspicuous place in the committee-clerk's office and the lobby. Members moving for the committee are to ascertain whether the gentlemen they propose to name will attend. To every question asked of a witness, the name of the member who asked it is prefixed in the minutes of evidence laid before the house; and the names of the members present at each sitting, and, in the event of any division, the question proposed, the name of the proposer, and the votes of each member, are entered on the minutes and reported to the house. [Committees.]

It is not intended to touch upon the elective franchise, or upon the proceedings at elections; but the mode of trying election petitions will require a notice in this place.

Trial of Election Petitions.—Before the year 1770, controverted elections were tried and determined by the whole House of Commons, as mere party questions, upon which the strength of contending factions might be tested. In 1741, Sir Robert Walpole, after repeated attacks upon his government, was at last driven from office by a vote upon the Chippenham election petition. "Instead of trusting to the merits of their respective causes," said Mr. Grenville, in proposing the measure which has since borne his name, "the principal dependence of both parties is their private interest among us, and it is scandalously notorious that we are as earnestly canvassed to attend in favour of the opposite sides, as if we were wholly self-elective and not bound to act by the principles of justice, but by the discretionary impulse of our inclinations; nay, it is well known that in every contested election, many members of this house, who are ultimately to judge in a kind of judicial capacity between the competitors, enlist themselves as parties in the contention, and take upon themselves the partial management of the very business upon which they should determine with the strictest impartiality." The principle of the Grenville Act, and of others which were passed at different times since 1770, was to select committees for the trial of election petitions by lot. By the last of these (9 Geo. IV., cap. 22), thirty-three names were balloted from the members present at the time, and each of the parties to the election was entitled to strike off eleven names, and thus reduce the number of the committee to eleven. Whichever party attended on the day appointed for a ballot in the greatest force, was likely to have a preponderance in the committee, and the expedient of chance did not therefore operate as a sufficient check to party spirit in the appointment of election committees. Partiality or incompetence was very generally complained of in the decisions of committees appointed in this manner, and in 1839 an Act passed establishing a new system, upon different principles, increasing the responsibility of individual members, and leaving scarcely anything to the operation of chance.

The following is an outline of the present mode of selecting members for the trial of election petitions:—At the beginning of a session the Speaker appoints a general committee of six members, to any or all of whom the house may object, in which case the Speaker is bound to appoint others. If by irreconcileable disagreement of opinion, or by the continued absence of more than two members, the committee, when appointed, should be unable to proceed in the discharge of its duties, or if the house should determine that it shall be dissolved, its functions are to cease. To this general committee all election petitions are referred. The names of all the members of the house are put into an alphabetical list and called over, when certain excuses are allowed to be made; but all who do not then excuse themselves from serving are bound to act as members of election committees when hereafter chosen. This list is taken by the general committee, from which are elected six, eight, ten, or twelve members, but in no case to exceed eighteen, who, on signifying their willingness to serve, are formed into "the chairman's panel." The list is then divided into five panels by the general committee, exclusive of the chairman, the order of which is decided by lot, and a number attached to each in the order in which it is drawn. These panels are to be corrected from time to time by the general committee, according to circumstances. The general committee gives three weeks' notice to the parties before it proceeds to appoint a committee for the trial of an election petition. At the expiration of that time it chooses, from the panel standing first in order of service, four members, whose names are read to the parties, who have power to object to any of them on grounds of disqualification specified in the Act. When the four members are finally chosen, the chairman's panel appoint one of their own body to act as chairman, who is added accordingly to the general committee. The committee, when thus completed, is sworn, and proceeds to business. All questions are decided by a majority.

As witnesses giving false evidence before an election committee are guilty of perjury, it is usual for the house, when acquainted with such misconduct, to instruct the attorney-general to prosecute the parties. The same course has also been pursued with respect to persons proved to have been concerned in bribery.

The determinations of election committees are final, and are immediately carried into effect by the house. If an election be reported void, a new writ is issued; if it be decided that a member has not been duly elected, and that another candidate should have been returned, the deputy clerk of the crown is ordered to attend and amend the return, after which the new member is sworn, and takes his seat; and if a petition or the opposition to it be held by the committee to have been frivolous and vexatious, the petitioner or sitting member, as the case may be, is liable to the payment of all the costs.

The last proceeding in parliament which we shall describe is that of *Impeachment.*—Impeachment by the commons is a proceeding of great importance, involving the exercise of the highest judicial powers by parliament; and though in modern times it has rarely been resorted to, in former periods of our history it was of frequent occurrence. The earliest instance of impeachment by the commons at the bar of the House of Lords was in the reign of Edward III. (1376). Before that time the lords appear to have tried both peers and commoners for great public offences, but not upon complaints addressed to them by the commons. During the next four reigns, cases of regular impeachment were frequent; but no instances occurred in the reigns of Edward IV., Henry VII., Henry VIII., Edward VI., Queen Mary, or Queen Elizabeth. The constitution "had fallen into disuse," says Mr. Hallam, "partly from the loss of that control which the commons had obtained under Richard II. and the Lancastrian kings, and partly from the preference the Tudor princes had given to bills of attainder or of pains and penalties, when they wished to turn the arm of parliament against an obnoxious subject." Prosecutions also in the Star-Chamber during that time were perpetually resorted to by the crown for the punishment of state offenders. In the reign of James I., the practice of impeachment was revived, and was used with great energy by the commons, both as an instrument of popular power and for the furtherance of public justice. Between the year 1620, when Sir Giles Montressor and Lord Bacon were impeached, and the Revolution in 1688, there were about forty cases of impeachment. In the reigns of William III., Anne, and George I., there were fifteen; and in George II. only one (that of Lord Lovat, in 1746, for high treason). The last memorable cases are those of Warren Hastings, in 1788, and Lord Melville, in 1805.

An outline of the forms observed in the conduct of impeachments may be briefly given. A member of the House of Commons charges the accused of certain high crimes and misdemeanors, and moves that he be impeached. If the house agree to it, the member is ordered to go to the lords, and at their bar, in the name of the House of Commons and of all the commons of the United Kingdom, to impeach the accused. A committee is then ordered to draw up articles of impeachment, which are reported to the house, and, having been discussed and agreed upon, are engrossed and delivered to the lords. Further articles may be delivered from time to time. In the case of Warren Hastings, the articles had been prepared before his impeachment at the bar of the House of Lords. The accused sends answers to each article, which are communicated to the commons by the lords; to these, replications are returned if necessary. After these preliminaries, the lords appoint a day for the trial. The commons desire the lords to summon the witnesses required to prove their charges and appoint managers to conduct the proceedings. Westminster Hall has been usually fitted up as the court, which is presided over by the lord high steward. The commons attend with the managers as a committee of the whole house. The accused remains in the custody of the usher of the black rod, to whom he is delivered, if a commoner, by the serjeant-at-arms attending the House of Commons. The managers should confine themselves to charges contained in the articles of impeachment. Mr. Warren Hastings complained of matters having been introduced which had not been originally laid to his charge, and the house resolved that certain words ought not to have been spoken by Mr. Burke. Persons impeached of high treason are entitled, by statute 20 Geo. II. c. 30, to make their full defence by counsel, a privilege which is not denied to persons charged with high crimes and misdemeanors.

When the managers have made their charges and adduced evidence in support of them, the accused answers them, and the managers have a right to reply. The lords then proceed to judgment in this manner: The lord high steward puts to each peer, beginning with the junior baron, the question upon the first article, whether the accused be guilty of the crimes charged therein. The peers in succession rise in their places when the question is put, and, standing uncovered, and laying their right hands upon their breast, answer "guilty," or "not guilty," as the case may be, "upon my honour." Each article is proceeded with separately in the same manner, the lord high steward giving his own opinion the last. The numbers are then cast up, and being ascertained, are declared by the lord high steward to the lords, and the accused is acquainted with the result.

(*A Treatise on the Law, Privileges, Proceedings, and Usages of Parliament*, by T. E. May, Esq., fourth edit., 1859.)

PARLIAMENT OF IRELAND. In Ireland, as in England, from the conquest of the country by Henry II. in the latter part of the 12th century, meetings of the barons were occasionally summoned to consult on public affairs, to which the old historians sometimes give the name of parliaments. But parliaments, in the modern sense, cannot be traced back in Ireland farther than to the latter end of the 13th century, or to a date about thirty years subsequent to that of the earliest parliament which is ascertained to have consisted both of lords and commons in England. Simon de Montfort's celebrated parliament, the first for which writs are extant summoning representatives of the counties and boroughs, met at Westminster in 1265; and the first Irish parliament to which, as far as is known, the sheriffs were directed to return two representatives for each county was held in 1295. Representatives of boroughs in Ireland cannot be traced much higher than to the middle of the 14th century. They first make their appearance in 1341, and in an act or ordinance of 1359 they are spoken of as forming an essential part of the parliament.

At this time, however, and down to a much later date, it was only the small portion of Ireland occupied by the English settlers that was represented in the legislature. Even in the reign of Edward III. only the province of Munster and a part of Leinster were considered as shire-land: they were divided into twelve counties. But in the course of the 15th century much the greater part of these districts had become to all intents and purposes independent of the English crown; and in the reign of Henry VII. the English dominion and the parliamentary representation were alike confined to the counties composing what was called the Pale, that is, to those of Dublin, Louth, Kildare, and Meath (then comprehending both East and West Meath), with a very few seaports beyond these limits. The vigorous measures taken under Henry VIII. and succeeding kings however gradually extended the authority of the English institutions and laws. The possessors of some of the original Irish peerages, after maintaining for centuries an independence as complete as that of the native chieftains themselves, were induced to give their attendance in the House of Lords, and many new peerages were conferred, some on Englishmen or persons of English descent, some on the heads of the old Irish families. The twelve ancient counties were all reclaimed in the reign of Henry VIII., and others were added by Mary, Elizabeth, and James, till, in the time of the last-mentioned king, the whole island was divided into thirty-two counties, as at present, each returning two representatives. Of these thirty-two counties however it is said there were seventeen in which there was not a single parliamentary borough, while in the remaining fifteen there were only about thirty. But either this account must be wrong or the common statement that James added only forty new boroughs must be an under statement, if, as appears, the entire number of the Irish commons in 1613 was 232. In this number however would be included the two representatives of Trinity College, Dublin. Subsequent new charters to boroughs augmented the house by the year 1692 to 300, at which number it remained stationary. In 1634 the number of peers was 122, and more than 500 Irish peerages were created between that date and the Union. Of course however some also became extinct.

It was only for a very short period of its existence that the Irish parliament was held to be a supreme legislature. Ireland being regarded as a conquered dependency, it was maintained that its parliament was in all respects subordinate to that of England, and subsequently to that of Great Britain, which might make laws to bind the people of the one country as well as of the other. The received legal doctrine used to be, that King John, in the 12th year of his reign (A.D. 1210), ordained by letters-patent, in right of dominion of conquest, that Ireland should be governed by the laws of England; in consequence of which both the common law of England and all English statutes enacted prior to that date were held to be of the same authority in Ireland as in England. With regard to English acts passed subsequently to that date, it was also held, in the first place, that Ireland was bound by all of them in which it was either specially named or included under general words. But further, inasmuch as one of the Irish acts called Poyning's Laws, passed in the tenth year of Henry VII. (A.D. 1495), in the lord-lieutenancy of Sir Edward Poyning, or Poynings, declared that all statutes "lately" made in England should be deemed also good and effectual in Ireland, it was held that this established the authority in Ireland of all preceding English statutes whatsoever; making those of the 12th of John of the same force with those enacted before that date. This however was admitted to be the last general imposition of the laws of England upon Ireland. Of the English statutes passed since the 10th of Henry VII., it was allowed that those only were binding upon Ireland in which that country was specially named or included under general words.

But the above-mentioned was only one of Poyning's laws. Others provided, as their substance is given by Blackstone (1 'Com.' 102): "1. That before any (Irish) parliament be summoned or holden, the chief governor and council of Ireland shall certify to the king, under the great seal of Ireland, the considerations and causes thereof, and the articles of the acts proposed to be passed therein. 2. That after the king, in his council of England, shall have considered, approved, or altered the said acts, or any of them, and certified them back under the great seal of England, and shall have given licence to summon and hold a parliament, then the same shall be summoned and held; and therein the said acts so certified, and no other, shall be proposed, received, or rejected." It was found, however, in the course of time, that many inconveniences were occasioned by these severely restrictive regulations, which prevented any laws from being proposed, except only such as were drawn up before the parliament which should pass them was in being; and therefore, by the 3 & 4 Ph. and M., c. 4., it was provided that any new propositions might be certified in England for approval, even after the summons and during the session of parliament. Still this left to the parliament of Ireland nothing more than merely the power of rejecting any law proposed to it; it could neither initiate a new law nor repeal an old one, nor even amend or alter that which was offered for its acceptance. In practice, however, the letter of the statute was somewhat relaxed. Blackstone goes on to state that the practice in his day (some years after the middle of the last century) was, "that bills are often framed in either house, under the denomination of 'heads for a bill or bills,' and in that shape they are offered to the consideration of the lord-lieutenant and privy-council, who, upon such parliamentary intimation, or otherwise upon the application of private persons, receive and transmit such heads, or reject them without any transmission, to England." These heads of bills however really differed in nothing from bills or acts of parliament, except that, instead of the words "Be it enacted," the formal commencement of each paragraph or clause was, "We pray that it may be enacted;" and the motion for presenting them scarcely differed, except in form, from the motion in the English House of Commons for leave to bring in a bill, a motion necessary in all cases to be assented to or carried in the affirmative before the actual bringing in of any bill. And as for the consent of the crown or the government, which it was necessary to obtain before either house of the Irish parliament could take up the consideration of any proposed law, with a view to its enactment, that would in practice probably be found to operate much in the same way with the assent of the crown, which even in England was necessary to give validity to any bill after it had passed both houses. In the Irish as well as in the English parliament there was in fact an opportunity of discussing the proposition without the permission of the crown. An English as well as an Irish bill required the assent of the crown before it could become law. This view of the matter has scarcely been sufficiently attended to in comparing the circumstances of the two legislatures. The practice of presenting heads of bills however was not introduced into the Irish parliament till after the Revolution. In the reign of Charles II., according to Lord Mountmorres, "the council framed bills altogether; a negative alone on them and their several provisos was left to parliament; only a general proposition for a bill, by way of address to the lord-lieutenant and council, came from parliament:" that is to say, all that the parliament was suffered to do was simply to request that some measure might be brought in for effecting a particular object. The object might be specified, but the means by which it was to be attained or attempted, in other words, the details and whole character of the measure, were to be left to the government. With regard to these, the parliament had only the power of accepting or rejecting them in the mass.

But the dependence of Ireland upon the English crown, and the consequent subordination of the Irish legislature, were held to go still farther than to the establishment of the principle that laws might be made by the parliament of England to bind Ireland. The Irish House of Lords had entertained writs of error upon judgments in the courts of common law from the reign of Charles I., and appeals in equity from the Restoration. Nevertheless, in the year 1719, a judgment in the Court of Exchequer having been reversed by the House of Lords, the question was carried to the House of Lords of Great Britain, by which the judgment of the Court of Exchequer was affirmed. On this the Irish House of Lords resolved that no appeal lay from the Court of Exchequer in Ireland to the parliament of Great Britain. But this resolution was immediately met by an act of the British parliament, the 6 Geo. I. c. 1, declaring that "the king's majesty, by and with the advice and consent of the lords spiritual and temporal of Great Britain in parliament assembled, had, hath, and of right ought to have full power and authority to make laws and statutes of sufficient force and validity to bind the people and the kingdom of Ireland; and that the House of Lords of Ireland have not nor of right ought to have any jurisdiction to judge of, reverse, or affirm any judgment, sentence, or decree given or made in any court within the said kingdom; and that all proceedings before the said House of Lords upon any such judgment, sentence, or decree are and are hereby declared to be utterly null and void to all intents and purposes whatsoever."

In this state the law remained till the year 1782. In that year the statute 6 Geo. I. c. 1, was repealed by the 22 Geo. III. c. 53; and the following year the 23 Geo. III. c. 28, declared the exclusive right and authority of the Irish parliament and courts of justice in all matters of legislation and judicature for Ireland. Finally, in 1800, by the Act of Union, the 39 & 40 Geo. III. c. 67, the Irish parliament was extinguished, and it was enacted that the United Kingdom should be represented in one and the same parliament, to be called the parliament of the United Kingdom of Great Britain and Ireland.

The earliest Irish statutes on record are of the year 1310; but from that date there are none till the year 1429, from which time there is a regular series. The whole have been printed, and there are also abridgments by Bullingbroke and Belcher, Hunt, and others.

(Wakefield's *Account of Ireland;* Hallam's *Constitutional History of England.*)

PAROCHIAL REGISTERS. [REGISTRATION OF BIRTHS, &c.]

PARODY (from the Greek παρῳδία, and that from ᾠδὴ, an ode). A parody is a pleasantry, which consists in turning what is intended as a serious composition into ridicule, by adapting it to some new purpose, or by the affected imitation of its peculiarities. It had its origin among the Greeks, from whose language the name is derived. It seems to be synonymous with the French *travestie.* Its most common form is that in which a performance, while its principal features are retained, is, by a slight change, diverted from its proper design, and made to bear a ludicrous signification. Sometimes the alteration of a single word, or even a single letter, is sufficient for the accomplishment of this. Another form of parody is that in which, without any change in the original, it receives a ludicrous character by its application to some object quite foreign to the original intention of the author. A third kind consists in choosing a mean and ridiculous subject, and treating it in the style and manner of approved writers; and a fourth, in exemplifying, in the illustration of any subject, the defects and absurdities of writers held in little esteem. Of the last two sorts of parody, more successful specimens will scarcely be found anywhere than those which occur in the work entitled 'Rejected Addresses.' The rules of parody have respect to the choice of the subject and the mode of handling it. It is necessary that the subject should be celebrated, or at least well known, and that in treating it there should be no departure from the requirements of good humour.

The term parody is also employed in music, and is given by the French writers to those pieces in which the words have been composed for the music and not the music for the words.

PAROL. This term, which signifies "a word," has been adopted from the Norman-French as a term of art in English law, to denote verbal or oral proceedings, as distinguished from matters which have been recorded in public tribunals or otherwise reduced to writing. Thus a parol contract is an agreement by word of mouth, as opposed to a contract by deed. Parol evidence is the testimony of witnesses given orally, as opposed to records or written instruments. This is the popular acceptation of *parol;* but, strictly speaking, everything, even in writing, is parol which is not under seal.

The formal allegations of the parties to a suit in the common law courts, called pleadings, which are now made in writing, were formerly conducted orally at the bar, and in the year-books are commonly denominated the *parol.* Hence in certain actions brought by or against an infant, either party may suggest the fact of the infancy, and pray that the proceedings may be stayed; and where such a suggestion was complied with, the technical phrase was that the *Parol demurred* (demoratus), that is, the pleadings were suspended until the infant had attained his full age.

PAROLE, the countersign, the pass word, or watch-word, given to guards and sentries in camp and garrison, and demanded by them of all who approach their posts, and on giving which alone they permit them to pass; also the promise, on honour, to reappear when called upon, given by a prisoner of war when allowed to go at large.

PARSLEY. The garden parsley (*Petroselinum sativum*) is a hardy biennial, a native of Sardinia, introduced into this country about the middle of the 16th century. There are three varieties, two of which are well known, and commonly used as pot-herbs, and for garnishing, namely: the *common* or *plain-leaved;* the *curled;* and the *Hamburg, large* or *carrot-rooted,* which last is cultivated only for its roots, occasionally used as young carrots. The curled variety is by far the most useful, and from its beautiful curled foliage it cannot be mistaken for the *Æthusa Cynapium,* or fool's parsley, a poisonous plant somewhat resembling the plain-leaved parsley. [ÆTHUSA, in NAT. HIST. DIV.]

The cultivation is simply that of sowing, usually in spring, in shallow drills about a foot apart; or in single rows along the borders of a kitchen-garden. The Hamburg requires to be sown in light and moist soil, such as would suit the carrot, like which it requires in all respects to be treated.

PARSNIP. The cultivated parsnip (*Pastinaca sativa*) is a native of England, and ranks amongst the hardiest of kitchen-garden productions, as is proved by the fact of its having withstood the intense frost of 1838, in the open ground. There are four varieties, namely, the *Common, Guernsey, Hollow-crowned,* and *Round* or *Turnip-rooted.* The Hollow-crowned has been found the best. The mode of culture is very simple. The soil ought to be deep and rather light, but by no means adhesive; and it should be trenched to the depth of at least two feet. In order that the roots may be clean and sound, fresh manure should not be applied; indeed if the soil be in tolerably good condition, no manure is required; and on the contrary, if it be poor, a more liberal supply should be given in the previous season, so that any immediate application along with the parsnip crop is not requisite.

The seed should be sown in March, and as early in that month as the weather and state of the soil will permit, in shallow drills eighteen inches apart, the plants being afterwards thinned to from 8 inches to a foot asunder in the rows. The roots are not in perfection for culinary purposes till their first season's growth is completed, which is indicated by the decay of the greater part of the leaves.

Some may be then taken up, their tops cut off, but not too closely, and the roots stored in sand in a cool place, so as to guard against the stimuli of light and heat as much as possible. This precaution of storing in the early part of winter is only necessary in case of frost becoming so severe as to render the operation of removal difficult; but the whole of the crop should be taken out of the ground before vegetation recommences in the spring, and treated as above.

Besides the use of the roots for the kitchen, a wine is sometimes prepared from them. Abounding in saccharine matter, they afford by distillation an ardent spirit, the process of fermentation being facilitated by the addition of a small portion of malt liquor.

The large Guernsey parsnip will yield under good cultivation 10 or 12 tons per acre of a most nutritive food for cows and pigs, for which the roots should be steamed or boiled.

PARSON. [BENEFICE.]

PARTHENON. [ATHENS, in GEOG. DIV.]

PARTICIPLE (in Grammar), the name of one of the parts of speech into which grammarians have distributed the words of a language. The word "participle" comes from the Latin word "participium," which is formed on the same analogy as "mancipium" and "principium," and means literally "part-taking." It is said, according to the old grammarians, to have obtained this name in consequence of its partaking of the nature both of the verb and the noun. Horne Tooke defines a participle to be a "verb adjective," which is perhaps as good a definition as can be given.

The English language has only two participles, which are usually called present and past. The present participle in *ing,* is a corruption of a fuller form which had a prefixed *a;* and this *a* was in truth an abbreviation of the old preposition *an,* signifying *in* or *on.* Thus, "he was a-walking" contains the same element as "he was a-bed;" and the word *walking* is merely one of the familiar substantives in *ing.* The Keltic languages form their participle in a way precisely similar; and the French too has inherited from this source the idiom *en disant*. The term *present* participle is however not very correct, as it often denotes the continuation of an action or a state of being independent of the notion of time. A better phrase is *imperfect* participle. This participle is called by some grammarians the *active* participle, but it is also passive; thus in the expression "he was building the house," the participle is active; but when we say "the house was building," it must be regarded as a passive. In such sentences as the preceding there is no ambiguity, but when we say "the man was killing," the knowledge of the subject can alone enable us to determine whether the man was active or passive. This ambiguity in the use of the participle in *ing* has led to the modern practice, which is gaining ground, of expressing the notion of a passive participle by means of the present participle of the verb "to be" and the past tense of the verb which is to be employed, as "being loved," "being praised," &c., which expressions are certainly very awkward and unwarranted by the usage of our best writers, if they are not absolutely wrong.

The other participle in English is used to denote past time, and is generally formed by adding *en* or *ed* and *d*, as *brok-en*, *praise-d*, &c.

PARTICLE, which is derived from a Latin word (*particula*) meaning a small part, is a term employed in grammar, but with rather an uncertain signification. Some of the old grammarians included under this name all the parts of speech except the verb and the noun, namely, prepositions, adverbs, conjunctions, and interjections. Words of this class are included under the term of "particles" by the Arabic grammarians. According to this definition, such words as "vehementer," "unexpectedly," &c., would be considered particles; which is certainly contrary to the common notion which we attach to a particle. In fact we seem to regard as particles all those small words which serve to make the sense of a proposition more clear and precise, though they might sometimes be omitted without rendering the meaning unintelligible. To this class of words belong the Greek *γε*, *αρα*, *τοι*, *δη*, *νυν*. &c., the English *when*, *yet*, *in*, *and*, *then*, *now*, &c.

PARTITION. [Parceners.]

PARTITION TREATIES. [Treaties, Chronological Table of.]

PARTNERSHIP may be defined to be a contract between two or more persons for joining together their money, goods, labour, and skill, or any or all of them, upon an agreement that the gain or loss shall be divided between them; and its object must be some legal trade or transaction. The English law of partnership is founded on the common law, the so-called law of merchants, and the Roman law. By the common law, a partner has no power to bind his co-partner by deed. By the law of merchants, he has power to bind his co-partner by a bill of exchange, and there is no survivorship in the partnership stock. From the Roman law is derived the principle that a partnership is terminated by the death of a partner. (Gaius, iii. 155.)

If the judges have any doubt about the custom of merchants, they may send to them to know their custom, as they may send for the civilians to know their law; but the judges only recognise those customs of merchants that are general, not those that are particular usages.

We have here to speak of private unincorporated partnerships, to constitute which no writing is necessary. The acts of the parties, when there is no partnership contract in writing, are the evidence of the contract. Partners may be either ostensible, nominal, or dormant. He whose name appears to the world as a partner is an ostensible partner. An ostensible partner may or may not have an interest in the concern; if he has no interest in the concern, but allows his name to appear as one of the firm, he is a nominal partner; if his name and transactions as a partner are purposely concealed from the world, he is a dormant partner; but if his name and transactions are actually unknown to the world, he is more properly termed a secret partner. Generally speaking, any number of persons may be partners; but there are some exceptions, for which see the article on Joint Stock Companies.

Any person of sound mind and not under any legal disability may be a partner. An infant may enter into this, as into any other trading contract which may possibly turn out to his advantage. It may, however, be avoided by him on coming of age, though the person with whom he contracts will be bound. An alien friend may be a trader and sue in personal actions, and may therefore be a partner. But an Englishman domiciled in a foreign country at war with England, or an alien enemy, cannot be a partner with a person in this country; at least he cannot sue in this country for a debt due to the firm. Married women are legally incapacitated from entering into the contract of partnership; and although they are sometimes, under positive covenants, entitled to shares in banking-houses and other mercantile concerns, yet in these cases their husbands are entitled to such shares, and become partners. If parties share in the profit and loss they are partners, although one may bring into the trade money, another goods, and a third labour and skill, which was also the rule of the Roman law (Gaius, iii. 149); and where one party is sole owner of goods and another sole disposer or manager of them, if they share the profits, they are partners in those profits. Every man who has a share of the profits of a trade must also bear his share of the loss; for a right to a share of the profit legally implies a liability to bear a share of the loss. Yet it is not necessary to the partnership contract that every party should undertake to share the loss, for one may stipulate to be free from all liability to loss, and such stipulation will hold good as between himself and his co-contractors, which was also the rule of the Roman law, though he will still be liable to all those who have dealt with the firm of which he is a member. Persons who jointly purchase goods are not partners unless they are jointly concerned in the profit or the produce arising from the sale of them. It is not necessary that the division of profit and loss among partners should be equal: it is sufficient that the parties share the profits, in order to render them partners. If they share the profits, they are by consequence bound to share the losses. But to constitute a man a partner on the ground of sharing profits, he must have an interest in the profits, as a principal in the firm; if he only receive a portion of the profits, by way of payment for his labour, trouble, or skill as a servant or agent of the concern, he is not a partner. Factors and brokers who receive a commission out of the profits of goods sold by them are not on that account partners with their principals; nor are persons who receive a certain share of the profits of an adventure, as payment in lieu of wages for acting as servants, partners in the adventure; nor even are persons who receive wages in proportion to the profits of the undertaking considered as partners. If a person lend money to a firm, and receives an annuity or interest, certain as to amount and duration, he is not a partner; but if he were to receive an annuity in lieu of the profits of the trade, and determinable on the event of the trade ceasing, it seems that he would be considered as a partner with the grantor of the annuity; or if he received an annuity varying in amount with the profits, he would be clearly a partner in the concern.

The contract of partnership must be formed for the purpose of some lawful trade, business, or adventure. If the subject of the contract be illegal, there can be no partnership founded upon it, so as to give the contractors a remedy against each other, or against third persons, at law or in equity; and if there be an illegal contract of partnership which is not executed, but executory only, none who are parties to it can by action or suit recover the money advanced for the purpose of establishing the partnership. A contract originally entered into for the purpose of evading the usury laws, and not *bonâ fide* with the view of partnership, could not, while those laws existed, be supported as a legal contract; nor can a partnership between attorneys, where one of them is not duly qualified, be sustained.

A person may stipulate not to be a partner, but if he shares the profit with those with whom he stipulates, he becomes a partner so far as relates to his liability to a third party. And if persons be known to share the profits of a trade, it is presumed that they are partners, and as such liable to all who deal with the firm, whatever be the private agreement among themselves. But they may repel the presumption of partnership by showing that the legal relation of partnership among themselves does not exist. If a person allow his name to be used in a business, or in any other way consent to appear as a partner, he will be so considered with respect to other persons, whatever may be his agreement with the firm; and he will be equally responsible to third parties with the other partners, although he may not receive or be entitled to receive any of the profits. The ground of this rule of law is clear and reasonable: a person must be considered bound by a contract, if he act in such a way as to make other contracting parties believe that he is a party to the contract; and such is the case with a man who allows his name to appear as a member of a firm, as to all contracts and dealings which are necessary for carrying on the business of the firm.

A partnership at will is one which continues as long as the parties live and are able and willing to continue it: a partnership for a fixed term continues for the term if the parties live and are of legal capacity to continue it. A partnership at will may be dissolved at any time by the express will of any member of it, a rule which is derived from the Roman law, and which is a necessary consequence of the nature of the partnership contract. In such case the partnership is dissolved immediately upon notice given by any of the partners. The effect of such dissolution is to stop all new partnership dealings or contracts; but the partnership still continues for the purpose of completing all contracts already made, and all dealings or undertakings already commenced. On such dissolution, any partner is entitled to have the whole partnership stock, and the interest in the premises on which the business is carried on, converted into money, and to receive his share of the produce. In all cases, by the natural death of a partner, the partnership is dissolved, a rule also derived from the Roman law, as already stated: it is also dissolved by a partner's civil death, as his outlawry, or attainder for treason or felony; for an outlaw, being dead in law, incapable of entering into any contract, bringing any suit, or holding any property, a partnership in which he is engaged is therefore dissolved; and, strictly speaking, the whole property is forfeited to the crown; for as the king never becomes joint tenant, or tenant in common with the other partner, the crown takes the whole; but this right is seldom enforced against creditors or innocent partners. A marriage of a feme-sole trader is also a dissolution of a partnership at will. A partnership for a term may be dissolved before its expiration by the mutual consent of the parties, by the decree of a court of equity, or by the bankruptcy, outlawry, or felony of any of the partners. A court of equity will in some cases dissolve a partnership on the ground of incurable insanity in one of the partnership. A partner may agree that upon his death the business may be carried on beyond the legal period of dissolution in the hands of his children or other third parties; but this is properly an agreement for a new partnership. Partners cannot be relieved from future liabilities to third parties without notice to them and to the world in general that the partnership has ceased; but in the case of a dormant partner, if none of the creditors know that he is a partner, no notice of his retirement from the firm is necessary; and if it be known to some, notice to such only will be sufficient. On the death of a partner, notice of the dissolution to third parties is unnecessary.

Partners are joint tenants in the stock and all effects; yet there is no survivorship in equity, or, as it has been said, at law, in such part of the stock as is moveable. Upon the decease of a partner, his personal representatives become entitled to his share of the moveable stock and effects, and they thereupon become in equity, and, as it has been said, at law, tenants in common with the surviving partners. If, as is generally the case in the purchase of lands for the purposes of a partnership, they are conveyed to the partners as tenants in common, and one of the partners should die intestate, the legal estate in his share will descend to his heir, who will be tenant in common with the other partners. If the lands were conveyed to them as joint tenants, there will be no survivorship in equity; and it becomes then a question whether, upon the death of a joint trader, who, with his partners, has so purchased lands for the purpose of the trade, his share will descend for the benefit of his heir or his next of kin; and the better opinion seems to be (see Darby *v.* Darby, 3 Drew, 499), that although the legal estate in freehold property purchased by partners for the purposes of their trade will go in the ordinary course of descent, yet the equitable interest will be held to be part of the partnership stock, and distributable as personal estate. It is scarcely necessary to observe, that upon the purchase of lands, they may be expressly conveyed so as to be always held as real estate, and descend to the heirs of the several partners.

It sometimes happens that one person supplies goods for an adventure, and another only his time, trouble, and credit; yet if in the agreement between the parties there are words which imply a joint undertaking, those words are evidence of an intention to share jointly the goods and also the profits of them.

There is an implied obligation, in the absence of express stipulation, among partners to use the property for the benefit of all of them: and any fraud on the part of one partner, either by misapplication of the partnership fund or in any other way, is a matter of which a court of equity will take cognisance. No partner has a right to engage in any business or speculation which must necessarily deprive the partnership of his time, skill, and labour, because it is the duty of each to devote himself to the interest of the firm. It is the duty of each partner to keep precise accounts, and to have them always ready for the inspection of his co-partner. Each partner is liable to the performance of all contracts of his co-partners, in the same manner as if entered into personally by himself, provided they relate to matters which are within the objects and purposes of the partnership. If the parties to the contract of partnership do not regulate it by express stipulation amongst themselves, the contract, with its duties and obligations, will be implied and enforced by the rules of law applicable to persons in such relative situations; and where the contract does not reach all the duties and obligations, such omissions will be supplied by the same rules of law. Though partners may have entered into a written agreement which specifies the terms on which the joint concern is to be carried on, yet, if there be such a course of dealing as leads to the conclusion that they have agreed to change the terms of the original written agreement, they will be considered to have done so. For instance, if the agreement be that no partner shall draw or accept a bill of exchange in his own name, without the concurrence of all the others, yet, if they afterwards adopt a practice of permitting one of them to draw or accept bills without the concurrence of the others it will be held that they have so far varied the terms of the original agreement. The transactions of partners are always to be looked to in order to determine between them, even against the written articles, what clauses in those articles will not bind them. It is impossible to state all the varieties of stipulation which are introduced into partnership articles; it will be sufficient to repeat that within the limits before laid down, the parties may enter into such stipulations as they please.

One partner may maintain an action of covenant against his co-partner, whether the covenant be for the payment of money or the performance of any act for commencing or establishing the partnership, or for the performance of any of the articles after the partnership has commenced; and if adequate compensation for the breach cannot be had at law, a court of equity will enforce a specific performance of the covenant itself. Courts of law do not allow actions of debt by one partner against another for money due upon simple contract, as for money laid out by one partner for the purposes of the partnership. The partner who is aggrieved must therefore enforce his remedy by action of account, or by an application to a court of equity, by filing a bill for an account and a dissolution of the partnership. A partner cannot maintain an action of debt against his co-partner for work and labour performed, or money expended on account of the partnership; if therefore he has a claim upon his co-partner for a sum of money due on account of the partnership, but not constituting the balance of a separate account, or a general balance of all accounts, his only mode of recovering the amount is by an action of account, or by a bill in a court of equity praying for an account, and usually also for a dissolution. If it turn out that an undertaking is impracticable, as if a machine, for the working of which the partnership was entered into, will not answer the purposes intended, and so the object of the parties is frustrated, or if either party commit fraud, or gross acts of carelessness or waste in the administration of the partnership, the party aggrieved has a right to a dissolution, and the same will be decreed in equity. A partner is also entitled to an account of the partnership assets against his co-partner, but it was formerly held that he could not have it pending the partnership. If therefore he filed his bill for an account, it was also necessary to pray for a dissolution. It is now considered that a partner may have such an account on stating a proper case, without asking for a dissolution; but considering the circumstances under which a partner files a bill for an account of partnership dealings, it will seldom happen that it will be his interest not to pray for a dissolution of the partnership. Where one partner has committed such breaches of duty as would warrant a decree for a dissolution, a court of equity will interfere summarily by injunction: as where one partner has involved the partnership in debt, or has himself become insolvent, the court will restrain him from drawing, accepting, or indorsing bills in the name of the firm, from receiving the partnership debts, and from continuing to carry on the business by entering into new contracts. It will also restrain an action brought by one partner against his co-partner on a separate and private account, upon payment by the latter of the money into court. So it will restrain the application of the partnership property to a use not warranted by the articles; or an execution against the partnership property for the separate debt of one partner. A court of equity will appoint a receiver where one partner excludes another from taking such part in the concern as he is entitled to take, and will do this even with a view to the continuation of the co-partnership, if it is for the benefit of the complaining partner, although such a step is usually taken with a view to a dissolution and winding up of the partnership affairs. Whether the party applying for a receiver wish a continuance or dissolution of the partnership, he must make out such a case to induce the court to interfere, as would authorise a decree for a dissolution.

Generally speaking one partner has an implied authority to bind the firm by contracts relating to the partnership, and he can do this by mere verbal or written agreements, or by negotiable securities such as bills of exchange and promissory notes. One partner may pledge the credit of the firm to any amount; but there are some exceptions to this rule. A dormant partner is in all cases liable for the contracts of the firm during the time that he is actually a partner; and a nominal partner is in the same manner liable during the time that he holds himself out to the world as a partner. Partners can make no arrangements among themselves which will limit or prevent their ordinary responsibilities to third parties. The power of one partner, above alluded to, to bind his co-partner, is implied in law, no express authority from the latter being necessary for that purpose; and in the case of bills of exchange, it exists by custom which has been judicially recognised. One partner may give a guarantee for himself and his partners, and the firm will be bound by it, if it be made in a matter relating to the partnership. The act and assurance of one partner, made with reference to business transacted by the firm, will bind all the partners. A partner will also be liable in respect of a fraud committed by his co-partner, if committed in the capacity of partner, in contracts relating to the co-partnership, made with innocent third persons. Thus, if a partner purchase goods such as are used in the business, and fraudulently convert them to his own use, the innocent partner, provided there be no collusion between the seller and the buyer, is liable for the price of the articles. But partners are not liable for the wrongs of each other, excepting where one partner acts as the servant of the rest, in which case the whole of the partners are liable to the consequences of any wrong he may do; and they may be proceeded against altogether, or one may be sued alone for the whole of the damage done. One partner has no implied authority to bind his co-partner by deed, yet if he execute a deed on behalf of the firm, in the presence of and with the consent of his co-partners, it will bind the firm. It seems that a release by one of several partners to a debtor of the firm binds the firm; but if such release be fraudulent, it will be set aside by a court of equity; and even a court of law will interfere to prevent a fraudulent release from being pleaded.

Where no time is mentioned in the deed of partnership for its commencement, the liabilities of the firm will commence from the date of the deed; but in adventures, unless the parties have previously held themselves out as partners, the liabilities commence from the time fixed by the contract. An in-coming partner is not liable for debts contracted before he joined the firm, but if he pay any of the old debts or interest upon them, or does other special acts, he may render himself liable in equity. In an adventure an in-coming partner is not liable for the price of the goods. When an infant partner comes of age, and does not disaffirm the partnership, if he wish to avoid being liable for the future debts, he must give the creditors notice of his disaffirmance: but for the past contracts he cannot be sued unless he promise to pay, or his ratification of the debts contracted in infancy be made in writing. On the retirement of an ostensible partner, notice of his retirement must be given, or he will be liable to the creditors of the continuing firm for subsequent contracts made by them, and such notice is usually given in the Gazette; but notice in the Gazette will not bind creditors who are not shown to have seen the notice. Third persons have a claim against a dormant partner for contracts entered into by the firm while he was a partner. This claim is founded on such dormant partner being actually a partner: and therefore it is unnecessary, on the dissolution of a partnership between an ostensible and a dormant partner, to give notice of the dissolution to the creditors, in order to protect the latter from subsequent contracts; for when the dormant partner has ceased to be a partner, he is relieved from all future liability.

It is collected from the majority of cases that a partnership contract is joint (not joint and several) both at law and in equity. Upon the death of a partner therefore the legal remedy against him in respect to the joint contract is extinguished, and the creditors can maintain an action against the surviving partners only. But the rule of equity as applicable to partners with respect to third parties was considered to be that the joint debts should be satisfied out of the joint estate; if that were insufficient, then subject to the claims of their separate creditors out of their separate estates proportionally; and if any of them were insolvent, then out of the remaining separate estates proportionally. But the case of Devaynes *v.* Noble (1 Mer., 529), since affirmed on appeal by lord Brougham (2 R & M. 495), has established the principle that a partnership contract is several as well as joint; and that a partnership creditor may have recourse for full payment to the estate of a deceased partner. And the same judge (Sir W. Grant) who decided that case, declared that a partnership debt has been treated in equity as the several debt of each partner, though at law it is only the joint debt of all.

It has been before said that notice of the decease of a partner to the creditors of the firm is not necessary to free his estate from future liability; but it is otherwise if one of the surviving partners be executor of the deceased. A deceased partner sometimes directs his executors to continue the trade; in that case his estate will be liable to the extent to which he directs his assets to be employed. If the executor exceed that limit, he becomes personally responsible.

In actions by partners, all the partners may, and all ostensible partners must, join as plaintiffs, unless the contract upon which the action is brought be in writing under seal, when only those partners who are included can sue thereon. But if a contract not under seal be made by some, for the benefit of themselves and others, those for whose benefit it is made, as well as those whose names appear on the contract, may sue. Parties to a legal partnership cannot recover upon an illegal contract, although its illegality, at the time it was made, were only known to one of the members of the firm. Persons who may legally be partners in foreign countries, as husband and wife, cannot sue here as partners, for by the law of England husband and wife are not permitted to sue as partners. On the other hand, partners trading abroad in such a manner as to make a partnership here, may sue as partners for consignments sent to this country, though they cannot sue as partners at the place of trading by reason of the particular law of that place. The construction of contracts is governed by the laws of the country in which they are made; but remedies must be pursued by the means pointed out by the law of the country whose tribunals are appealed to. The laws of the country where the contract was made can only have a reference to the nature of the contract, not to the mode of enforcing it. If partners have occasion to prefer an indictment relating to the partnership property, such property may be stated in the indictment as belonging to one of them by name, and to another or others, as the case may be. But though it is not necessary to name all the partners, yet where there are other partners, that fact should appear in the indictment, or the prisoner must be acquitted.

A whole firm may become bankrupt, or some or one only of the partners may become so, whilst the remaining members may be solvent; but those only of the partners who have committed acts of bankruptcy are to be deemed bankrupts; and to constitute two or more bankrupts under a single adjudication, there must be evidence of joint trading. Upon the bankruptcy, the whole of the bankrupt's property vests absolutely in the assignees, who have the same remedy by action for the recovery of the debts due to the bankrupt, and for the redress of all civil injuries with respect to the property passing to them under the adjudication, as the bankrupt would have had if none had been made. Accordingly, when the bankruptcy is separate, the solvent partners join with the assignees in an action for the recovery of the joint debts. On the bankruptcy of one partner, the solvent partners become tenants in common with the assignees of all the partnership effects. Upon the bankruptcy of one partner, under a separate adjudication made against him, his assignees take all his separate property and all his interest in the joint property; and if a joint adjudication issue against all, the assignees take all the joint property, and all the separate property of each individual partner. Joint estate is that in which the partners are jointly interested for the purposes of the partnership at the time of the bankruptcy. Separate estate is that in which the partners are each separately interested at that time. Joint debts are those for which an action, if brought, must be brought against all the partners constituting the firm; in all cases therefore when a partner becomes liable for a debt contracted by his co-partners, a joint debt is created, and the creditor is a joint creditor of the firm. Separate debts are those for which the creditor can have his remedy at law against that partner only who contracted them.

The rules relating to joint-stock companies, banks and mining adventures not regulated by charters of incorporation or special custom were formerly exactly the same as those of any other kind of partnerships. But recent legislation has considerably modified the position of these associations, by introducing under certain restrictions, the principle of *limited liability*. The stat. 19 & 20 Vict. c. 47 (1856) amended by some subsequent acts, now regulates most joint-stock companies. The stat. 20 & 21 Vict. c. 49 (1857), and 21 & 22 Vict. c. 91 (1858) apply to joint-stock banking companies, the latter statute enabling these bodies to avail themselves if they please of the principle of limited liability. For more detailed information the reader is referred to the article JOINT-STOCK COMPANIES.

A bill for consolidating the enactments on this subject was introduced in the late session of parliament (1860), but did not pass into law.

The legal condition of part-owners of ships is considered under SHIP.

The chief rules of Roman law as to partnership may be collected from Gaius, iii. 148-154; 'Dig.,' xvii., tit. 2; Cicero, 'Pro Publio Quintio.'

(Collyer 'On Partnership,' and Blackst. Comm., v. ii., p. 526, Mr. Kerr's edition.)

PARTY WALLS. [BUILDING ACTS.]

PARVISE (*parvis*, in French), an old term for an open area or porch before the principal entrance of a church. It appears to have been used only or chiefly with reference to a cathedral or other large church. The older French writers term the pronaos of the Parthenon, or the outer circuit of the temple at Jerusalem, a parvis. By modern English writers on Gothic architecture, the room sometimes seen over a church porch is called a parvise. These rooms, which are often of later date than the porches, are supposed to have served as the private oratories of chantry priests, or as some think, to have been occupied by anchorites or recluses. Examples of these parvises occur at Fotheringhay, Northamptonshire; Sherborne, Dorsetshire; Harrow-on-the-Hill, Middlesex, &c.

PARVOLINE ($C_{18}H_{13}N$). An organic alkaloid found in Dorsetshire shale-tar. It is isomeric with cumidine.

PA'SHA or BASHA, a Turkish appellation for a man in high command, such as the great officers of the Porte, the governors of provinces, and the high admiral, who is called Capitan Pasha. The provinces administered by Pashas are called Pashaliks. The Turks often write the word Pashah with an h at the end, as if it were a contraction or corruption of the Persian word Padishah, which is a compound of Pad, "a guardian," and Shah, "a king," and which is the title assumed by the Ottoman Sultan, the king of Persia, the Mogul and other great Eastern potentates. (Herbelot, 'Bibliothèque Orientale.') Some derive Pasha from the Persian Pai Shah, "the foot of the king," because those officers tread in the steps of the sovereign and stand in his place. ('Continuation' to D'Herbelot, vol. iv., 4to. edition, 1779.)

PASQUIN, the name given to a mutilated ancient statue which stood at the corner of the palace Santobuono, in a small open place in the city of Rome, near the Piazza Navona. It represents a warrior in the attitude of defence. The subject of the statue is not known. Pasquino was the name of a tailor who lived in that neighbourhood "many years since," says Parisio, in his 'Antiquities of Rome,' published A.D. 1600. The shop of Pasquino was a sort of place of meeting for the people of the district, who came there to tell or hear the news of the day, as is still the custom in the apothecaries' shops in the provincial towns of Italy. The tailor was a facetious man, and his witty sayings were styled "Pasquinate," which afterwards became a common appellation for humourous epigrams and sarcastic lampoons, a kind of composition for which the modern Romans are noted. These lampoons, which often attacked people in high stations and the government itself, were fixed in the night on or near the statue already mentioned; and thus the statue itself came to be called Pasquino, as being the representative of the witty tailor of that name. Collections of these epigrams have been made, and some of them are very witty, though often scurrilous and coarse.

PASSENGERS. [SHIPS.]

PASSIVE VOICE. [MIDDLE VOICE.]

PASSOVER (פֶּסַח, *a passing over*, or *sparing*, *πάσχα*), also called the feast of unleavened bread, one of the three great annual festivals of the Jews, was established to commemorate God's passing over the houses of the Israelites in Egypt when he slew the first-born of the Egyptians (Exod. xii. 27). It was first observed in Egypt on the night before the Exodus. It began on the evening after the 14th day of the month Abib, or Nisan, which was the first month of the sacred year, and lasted seven days, the first and last of which were observed as especially holy by abstinence from all labour, and by a convocation of the people for worship. After the settlement of the Israelites in Palestine, it was incumbent on all their males to go up to the Temple to keep this feast. The following were the ceremonies observed in its celebration:—A lamb, or kid, a male of the first year, without blemish, was selected by each household (or if the households were small, by two conjointly) on the 10th day of the month, and it was kept till the 14th day of the month, when it was killed in the evening (literally, "between the two evenings," an expression which is variously interpreted), and roasted, and eaten with unleavened bread and bitter herbs. None of it was to be left till the next day: all that was not eaten was to be burnt. They were to eat it in haste, standing, with their loins girt, their shoes on their feet, and their staves in their hands, as those prepared for a journey. None, whether Israelites or strangers, were to partake of it unless they had been circumcised. Not a bone of the paschal lamb was to be broken, and all of it was to be eaten in the same house. When the lamb was killed, its blood was sprinkled with a bunch of hyssop on the lintel and door-posts of the houses, which was intended, in the original institution of the feast, as a sign to distinguish the houses of the Israelites from those of the Egyptians; and no one was to go out of doors till the morning.

During the seven days for which the feast lasted none but unleavened bread was to be eaten, on penalty of being cut off from the people. Sacrifices were appointed to be offered on each of the seven days (Numb. xxviii. 17-25). On the second day of the feast a sheaf of corn was to be brought, as the first-fruits of the harvest, and the priest was to wave it before the Lord. (Levit. xxiii. 10; Joseph., 'Ant.,' iii. 10, 5).

The word passover is used not only for the feast, but also repeatedly for the paschal lamb itself.

This institution was typical of the death of Christ for the salvation of his people (1 Cor. v. 7); and it was at the passover that the Lord's supper was instituted.

(Winer's *Biblisches Realwörterbuch*, under 'Pascha;' Lightfoot's *Temple Service*, c. 12.)

PASSPORT, a printed permission signed by the secretary of state of the home department of a country, or some other constituted authority, which allows a subject of that country to leave it and go abroad. When he has obtained this, the bearer must have his passport signed by the minister or agent of the state to which he intends to proceed. A foreigner who wishes to leave a country where he has been residing, generally obtains his passport from the minister or agent or consul of his own state. Such a document states the name, surname, age, and profession of the bearer, and serves as a voucher of his character and nation, and entitles him to the protection of the authorities of other countries through which he may pass, and which are at peace with his own. On arriving at the outports or frontier towns of a foreign state, every traveller is obliged to show his passport, which is examined by the proper authorities and signed, or viséd, before he is allowed to proceed on his journey. This ceremony is sometimes repeated at every garrison town which he passes on the road. Even the natives of most European states cannot travel twenty miles through their own country without being furnished with a passport. In Great Britain passports to foreign countries are granted by the secretary of state for Foreign Affairs, by whom also agents are appointed at many of the British ports, who are authorised to grant passports to British subjects.

The system of passports is old. The only civilised countries in which passports are not required are the British Islands and the United States of North America; and the natives of those two countries, accustomed to the freedom of unobstructed locomotion, find the regulations as to passports when they travel on the continent of Europe to be rather irksome. The practice has been defended on the plea that it prevents improper and dangerous persons from introducing or concealing themselves; but numerous instances have proved that persons, however obnoxious, who have money and friends, can evade such restrictions. That every state may admit or refuse admittance to foreigners, as it thinks fit, cannot be questioned; and in times of war especially, some sort of restriction may be required for the safety of the country; but the present system of passports, as enforced in many European states in time of profound peace, is both illiberal and puerile. It is a check upon travellers, to whom it causes much trouble and loss of time, while the advantages supposed to result from it are at least very dubious. It has been compared to spiders' webs, in which flies are caught, but which larger insects or birds easily carry off along with them. In Turkey a passport is called a Firman.

PASTES. [Glass.]

PA'STORAL (from the Latin *pastor*, a shepherd or herdsman), is the name given to poems which are descriptive of the pursuits of country life, or to dramas in which the characters represent shepherds or other country-people. [Bucolics; Idyll.]

Pastoral letters are circulars addressed by a bishop to his diocesans for purposes of religious instruction or admonition in matters of discipline. This name also is derived from "pastor," the bishop being styled the shepherd of his spiritual flock.

PASTURE, COMMON OF. [Commons.]

PASTURE LAND. There are tribes which have no other occupation than that of pasturing domestic animals, and immense tracts of fertile soil are still unappropriated to any definite owner. Where the climate is genial, and the extremes of heat and cold are unknown, cattle are fed all the year round by moving from one place to another. In such a state are some of the wandering tribes of Asia, who have no fixed habitations, but pitch their tents wherever pasture is abundant, and move them to another spot as soon as it is consumed where they are. In civilised countries, where the land is divided and appropriated, such a system cannot exist; though there are still traces of it in this country, as we see in the few remaining waste lands, on which there is a right of common.

The pasturage of cattle is now a part of regular husbandry; the land which affords the herbage for cattle forms part of private possessions, and a rent is paid for its use. This has introduced a new system. Pastures are now fenced and protected, and pains are taken to improve them, so as to maintain many more cattle or sheep than they would in their natural state. We shall not here speak of rich grass lands, in which bullocks and sheep are fatted, and which are commonly called grazing land; nor of artificial pastures, which form portions of arable farms, and have been depastured only to enrich them and make them more fit to produce corn when again submitted to the plough. But we shall consider those tracts of land which, from situation, climate, or other causes, although they are portions of certain estates and the property of individuals, lie nearly in a state of nature, and produce a revenue or profit only according to the number of cattle and sheep which can be reared or maintained in them. Such are the rich pastures on the Jura, the Alps, and Pyrenees, too high and exposed to allow of cultivation or permanent habitation, but producing abundant food for cattle in particular seasons of the year. The Jura and the Alps, which are best known to English travellers, contain very rich pastures for cows, and give a considerable return in butter and cheese. The snow which covers these mountains for a considerable part of the year, protects the herbage; and the moisture which prevails in the summer by the continual passage of clouds, which appear in the form of heavy fogs to those who are enveloped in them, keeps up a luxuriant vegetation of the small Alpine plants which form the richest pasture.

Whenever pastures are hired, the rent is always reckoned, not by the extent of surface, but by the stock which can be maintained upon it. Thus, in Switzerland, the mountain pastures are divided into portions of twenty, forty, or more cows. This mode of reckoning is much fairer than by mere extent of surface. In many places pasturing has been found much more productive than cultivation; and some large proprietors have converted great tracts of land from arable into pasture farms. But this can only be done where the population is very scanty, and where the soil and climate do not tempt men of capital to settle.

Considerable improvements have been made in natural pastures, not only by the raising of banks and stone walls as shelter against the winter's storms, but also by extensive draining and clearing the surface of wild plants and shrubs, which prevent the herbage from springing up, and greatly diminish the feed. On the sides of steep hills, where springs are apt to break out and produce bogs and swamps, drains judiciously made have carried off the water and laid dry the pastures below them; while reservoirs have been constructed in many places to receive the water and to supply the stock in dry weather. On peaty moors the application of lime to the surface has often produced wonderful effects, and made various kinds of clover and grasses spring up which were never seen on the spot before.

Those who are possessed of extensive pastures often look upon them as of too little value to lay out any money in their improvement; and unless when an attempt is made to bring them into regular cultivation, which often fails after a great outlay of money, they are not thought worth any attention. Yet many rough hilly pastures might be doubled and tripled in value merely by clearing the surface, burning coarse grasses, rushes, ferns, and furze; and sowing a few seeds where the ashes have been spread. The additional number of cattle or sheep which can be maintained by this means, would surprise any one who had not had experience of such improvements. The forming of convenient channels for the water to run off is another important object, which can often be effected at a trifling expense; and a loose surface laid dry by this means may be much improved, by merely burning the heath which grows upon it. After the fire has scorched the ground, grasses will spring up spontaneously; and, at a very small expense, a considerable tract of mountain pasture may be converted from the state of a brown heath or moor to that of a fine green sward.

Wherever there are large pastures, proper and suitable buildings made of substantial materials should be erected. The cattle should have numerous sheds for refuge in bad weather, and sheep especially should have protection and shelter. Warmth is in some cases of as much importance as food; and an animal exposed to all the severities of a northern climate requires more food to keep him alive, than when he is kept warm and protected from the immediate influence of cutting winds.

There is another kind of pasture in England on the chalky hills which are called downs, where useful and hardy sheep are reared. Here the exposure is less, and the proximity to the plains gives frequent opportunity of driving the sheep to sheltered situations. The grass on the chalk hills is in general very fine and short, and the quality is very good. The soil is only a few inches deep, and has been robbed for generations by the pasturage of sheep during day, which at night are folded on arable land in their neighbourhood for the sake of the manure which they drop, nevertheless it annually produces a crop of close good pasturage. Attempts are made occasionally to convert some portions of these pastures to tillage: but it is not often an advantageous speculation. A few crops may be obtained at first; but the thin layer of rich earth, which is at its surface, is soon exhausted, and nothing remains but barren chalk. No art can restore the fine turf which had been produced by ages of pasturage.

Very poor pasture on sandy or gravelly loams is of very little value to the proprietor. Where the situation allows of such land being converted into plantations, it will generally be found most advantageous to do so, but if there are means of improving them by ploughing, liming, and manuring, they may often be converted into good arable farms. A great part of Norfolk, which now bears excellent crops of barley, wheat, and clover, was once only poor sandy pasture, where the chief income to the proprietor arose from rabbit warrens. We must not always judge of the capabilities of a soil by the natural grasses which grow upon it, before it has ever been stirred and cultivated. When loamy sand or gravel is left in a hard condensed state, it will bear very little, but when it has been broken up deep, and trenched and improved by lime, marling or claying, and manure, it becomes very useful land. The same may be said of cold wet pastures on a stiff clay, the means of improvement then being drainage, burning, and deep culture. The water checks the roots of the better sort of grasses, and nothing thrives in such pastures except rushes and very coarse aquatic plants; but when they have been carefully drained—when the surface has been pared and burnt, and the ashes spread over the land—a very material improvement takes place, whether it be left unbroken, to produce herbage, or be improved by a course of judicious cultivation, and laid down again to grass in a clean and fertile state; in either case, the pasture, from being of little use, and perhaps dangerous for sheep, which are apt to rot there, becomes sound and good, producing excellent nutritious herbage, and will continue so ever after.

Pastures are seldom improved with manure, which is generally reserved for arable land, or grass land intended to be mown for hay: but if richness is valuable in a pasture, it will well repay the expense of manuring, especially with liquid manure, the drainings of dunghills and the urine of cows and horses, which is collected in a tank when they are kept in stalls. Peat ashes are also very useful, and have a powerful effect in stimulating the vegetation of all the grasses. Saltpetre and nitrate of soda are said to have the same effect. When it is intended to convert land which has been in a state of heath or waste, covered with fern, brambles, ling, and other coarse plants, into good pasture, it is indispensable to begin by a course of arable cultivation; and it is only when the soil has been brought into an improved state by tillage and manuring, and all the roots and seeds of noxious plants have been eradicated, that grass seeds may be sown with any prospect of obtaining a good sward. Most of these soils are poor and sandy, and not very favourable to the growth of good grass. In this case the safest mode of converting the land into pasture is by inoculating it with pieces of sods taken from a good rich pasture. [GRASS LAND.] By this means, and subsequent depasturing with sheep only, very good pastures have been produced on very poor soils; and if in the course of a few years they should degenerate, they may be profitably broken up and cultivated on the convertible system of husbandry, after which they may again be laid down for a certain number of years. Wherever the soil consists of a sandy or gravelly loam, this system is the most advantageous. As to choice of manures, it is found that ammoniacal manures tend to the growth of the grasses, and that phosphate and mineral manures tend to the growth of clover and leguminous plants.

In the richest pastures, such as those of Lincolnshire and other grazing counties, an acre will maintain and fatten an ox of 80 or 90 stone, and sometimes keep several sheep in store order besides. There is a marked difference between land that will fatten an ox, and that which will only rear him. This can scarcely be discovered by simple examination of the land; but is found by experience. The same appearance of grass has more *proof*, as it is called, in one place than another. The bite may be very short, and the pasture appear bare, and yet the value of it may be seen on the ribs of the cattle. Much of the skill of a grazier consists in stocking his pasture to advantage. He should know the power of every portion of it, and stock it so that the grass may not grow faster than it can be cropped by the cattle or sheep, and that the animals may always have the full quantity required. Every animal wants a certain quantity of food to repair the daily waste occasioned by the animal functions. If he has no more, he makes no progress: the more he can convert into flesh and fat beyond this quantity in a given time, the more profitable he will be. Hence the superior qualities of some animals with respect to this point indicate the superiority of their breed, and afford the greatest net profit to the grazier. In the same pasture one beast or sheep will give a reasonable profit, while another may occasion an actual loss. The adaptation of the stock to the nature of the pasture is consequently an object of the greatest importance, and requires much judgment and experience.

PATENA (*Patène*, French), a small circular plate, or salver, employed in the Roman Catholic church in the celebration of the eucharist. From the earliest time the form has scarcely varied. Patenas were frequently made to serve as a cover to the chalice. They were usually of gold, silver, or latten: some which have come down to us are richly ornamented with gems, enamels, or engraved work, and afford exquisite examples of mediæval art.

PATENT. This term is now ordinarily applied to exclusive rights of manufacture granted by royal letters patent under the provisions of the Statute of Monopolies, 21 Jac. I. c. 3, and subsequent statutes. Prior to the Statute of Monopolies it had become not unusual for our Tudor sovereigns to grant by their letters-patent to their favourites and to purchasers, exclusive rights of trading, in derogation of the old common law; and this statute was passed to restrain such abuses, and to settle and determine the circumstances under which encouragement and protection should be afforded to inventors. While therefore the statute commences with a declaration of the illegality of monopolies, it proceeds to except therefrom "all letters patent for the term of fourteen years or under, by which the privilege of sole working or making any new manufactures within this realm, which others at the time of granting the letters-patent shall not use, shall be granted to the true and first inventor thereof; so as they be not contrary to law, nor mischievous to the state, nor to the hurt of trade, nor generally inconvenient;" and within the terms of this exception all valid patents may still be ranged. The grant of a patent is not a thing which the subject can claim as a matter of right; it is the free gift of the crown. The form of the grant is by letters-patent under the great seal, which being the deed of the crown are considered as of public record.

Before applying for a patent for an invention, two considerations are necessary; first, what is entitled to a patent; and next, whether the invention has the requisite conditions.

In the first place, the machine, operation, or substance produced, for which a patent is solicited, must be new to public use, either the original invention of the patentee, or imported by him and first made public here. A patent may be obtained for England, Ireland, or Scotland, although the subject of it may have been publicly known and in use in either or in both of the other two countries.

In the second place, the subject of the invention must be useful to the public, something applicable to the production of a vendible article, this being the construction put upon the words "new manufacture" in the statute of James I. The discovery of a philosophical principle is not considered entitled to such protection: such principle must be applied, and the manner of such application is a fit subject for a patent.

Inventions entitled to patent may be briefly enumerated as follows:—

1. "A new combination of mechanical parts, whereby a new machine is produced, although each of the parts separately be old and well known.

2. "An improvement on any machine whereby such machine is rendered capable of performing better or more beneficially.

3. "When the vendible substance is the thing produced either by chemical or other processes, such as medicines or fabrics.

4. "Where an old substance is improved by some new working, the means of producing the improvement is in most cases patentable."

If the inventor think that the machine, operation, or substance produced comes under any of these enumerations, he may lodge with the Commissioners of Patents for Inventions a petition to the crown for a patent, supported by a declaration in lieu of an oath, that he is the true and first inventor of the manufacture sought to be patented, and that the invention is not in use by any other person to the best of his knowledge and belief. With this petition and declaration must also be lodged an instrument called "the provisional specification," the object of which is to describe the nature of the invention. The applicant is then referred by the commissioners to one of the law officers of the crown, who is at liberty to call any scientific or other person to his aid; and if the law officer shall be satisfied that the provisional specification describes the nature of the invention, and certifies his allowance of the same, the invention may, during six months from the date of the application, be used and published without prejudice to any letters-patent to be afterwards granted; or the applicant may file with the petition and declaration a "complete" in lieu of a "provisional" specification, inserting in the declaration an additional statement, that the instrument particularly describes and ascertains the nature of the invention, and in what manner the same is to be performed; and in this case the applicant has, during the term of six months, the like powers and privileges as under letters-patent during term the invention may be used and published, without prejudice to the subsequent grant of letters-patent.

The next step is for the applicant to give notice at the office of the commissioners of his intention to proceed with his application, which is then advertised by the commissioners; and any person having an interest in opposing the grant of the letters-patent will be at liberty, within a certain period, to lodge particulars in writing of their objection, and to be heard in support of them. The period for objection being expired, the specification and the objections are referred to the law officer, who, if the application seems to him fit, may cause a warrant to be made for the sealing of the letters-patent; which warrant having been sealed by the commissioners, has next to be, under the sanction of the lord chancellor, sealed with the great seal of the United Kingdom, whereby the grant to the applicant, of the exclusive right of using the invention within the United Kingdom, the Channel

Islands, and the Isle of Man, and (if the warrant so direct) within the colonies, for the full term of fourteen years, is completed. A patent right may, however, at the option of the patentee, be limited to a preliminary period of three, and successive periods of four and seven years, in which case the amount of the fees is also distributed. The letters-patent always contain a proviso to the effect that, if the "complete specification" already filed does not particularly describe the nature of the invention and the mode of applying it,—or, supposing no such specification to have been yet filed, then, if the applicant does not within a limited period file such a specification in the Court of Chancery, the grant in the letters-patent contained shall be void. The object of the specification thus required, is to put the public in full possession of the inventor's secret, so that any person may be in a condition to avail himself of it, when the period of exclusive privilege has expired. To prevent this object from being defeated by an evasive or careless description, the proviso is construed with great strictness by the courts of law; and it is held to be infringed, and the letters-patent to be consequently void, whenever the specification is in any part of it materially false or defective. The principal rules on this subject are as follows:—In describing the nature of the invention, the specification must, in the first place, correspond with the title of the patent, for its office is to set forth with more particularity the subject already indicated in the patent itself; and if one thing be claimed by the patent, and another by the specification, the grant is void. It is also an objection to the specification, if it should cover too much; that is, include in its claim of *new* invention anything which in fact has been already known and practised; and therefore if the entire article for which the patent has been taken out comprises some known process in connection with others that are new, the claim should be made in such form as to apply to the latter only, and to disclaim the former; or if the combination of several known things happen to be the only novelty, it is to the combination only that the claim should be pointed. As to the description of the manner of performance or production, the general rule is, that it should be such as to enable workmen or other qualified persons of ordinary skill to make the patent article at the expiration of the term, by simply following the directions given, without resorting to contrivances of their own. In addition to which we may remark, that no circumstance can be safely passed over in this description which is advantageous, whether absolutely essential or not, in the conduct of the process; and that if several methods are stated, the specification will be defective if *either* of them be found to fail in effecting the promised result.

The following are a few instances of patents being lost through defective titles:—

In the case of King *v.* Metcalfe (2 Starkie, N.P.C., 249), the subject of the patent was a hair-brush, in which the hairs were of unequal length: in the title it was described as a "tapering brush," which was considered as intended to mislead the public, as not being a description of the subject of the patent, and it was annulled accordingly. In Cochrane *v.* Smethurst (K. B., 1 Starkie, 205), the patent was for a certain lamp, but the title called it an "Improved Method of Lighting Cities, Towns, and Villages." The patent in this case was held to be void, as the specification only described a new lamp, and not an "improved method of lighting" at all; and it was also objected, that as it was equally applicable to lighthouses, harbours, shipping, &c., the title was otherwise imperfect. If the title had been for an "Improved Lamp" or an "Improvement on Lamps," the patent would have been valid. In the case of King *v.* Wheeler, the patent set forth in its title a "New and Improved Mode of Drying and Preparing Malt," whereas the specification described a method of re-burning malt which had already been made, so as to produce a colouring matter for beer and other liquors. Now it is evident that if any one had intended to take out a patent for producing colouring matter, he would never have collected from this title that the patent was likely to interfere with his invention. In the case of Bloxam *v.* Elsee (6 Barn. & Cress., 169 and 178), the title of a patent which came in question was "A Machine for making Paper in Single Sheets, without Seam or Joining, from 1 to 12 feet and upwards in width, and from 1 to 45 feet and upwards in length." The specification, however, described a machine only capable of producing paper of one width or to a certain width. Now if an inventor who thought of taking a patent for a machine to make paper of a greater width than 12 feet had looked at the title only of this patent, he would have supposed that such a patent already existed; but if he had inspected the specification, he would have found that it did not bear out the title, as the machine therein described was not capable of making paper of a width greater than 12 feet. The patent then was invalid, as the title comprised more than the specification. This is the most common error that patentees fall into. Jessop's case, cited during the trial of Boulton and Watt against Bull, in 1795, by Mr. Justice Buller, is another instance. A patent was taken out for a "New Watch," whereas the specification only described a particular movement in a watch, which was the real invention, and the patent was therefore void.

Patentees sometimes render their patents invalid by claiming too much; thus, after describing one substance or process which will answer a certain purpose, they often conclude by some such expression as, "or any other fit and proper means." The following is an instance in which a patent was set aside by such an expression. In specifying a machine for drying paper by passing it against heated rollers by means of an endless fabric, the inventor, after describing one sort of fabric, the only one in fact which he used, went on to say that any other fit and proper material might be used. Now if he used any other means of effecting his object, such means should have been distinctly described. This alone rendered his specification incomplete; but, besides this, it was proved that no other fabric would answer the purpose, or rather that no other was known, and the patent was annulled accordingly.

The patentee may describe his invention just as he pleases, and he may illustrate such description by drawings or not; but he should be careful to use words in their most common acceptation, or if some technical use should have perverted their meaning, he should make it appear distinctly that he intends them to be taken in such perverted sense.

An honest and valid title may be stated in a few words to be a description of the precise object of the invention in the most simple language.

A patent right is *assignable;* and the assignment of it must be in writing, under hand and seal. It is of course personal property, and as such passes by will. The patentee may, without alienation of his entire interest, grant deeds of *licence* to other persons to manufacture the article.

In favour of patentees who have not reaped the full benefit of their inventions, the legislature has frequently interfered, by passing private Acts of Parliament to secure them the continuance of their privileges for a further term of years, in addition to that first limited by the letters-patent. But a less costly mode of relief is now provided; and where the invention is meritorious, and the parties interested have done all in their power to bring it out and to turn it to advantage, but owing to circumstances beyond their control they have been unable to obtain an adequate remuneration, they may now apply *by petition* to Her Majesty in council for a prolongation of the existing term; and if, upon consideration of the whole matter, and after hearing any party who may choose to enter a "caveat," the judicial committee of the privy council shall report in favour of the application, Her Majesty is empowered to grant to such patentee (or to his assigns, or to both conjointly, as the case may be) new letters-patent, for any term not exceeding fourteen years after the expiration of the first.

If a patent right be infringed the inventor has his remedy, by action, to recover damages for the injury sustained; and may in such action, by application to the superior court in which it is brought, obtain an order for restraining the wrong-doer from the further use of the invention, and compelling him to account for the profits which he may have already derived from a sale of the article; an order which may also be in some cases obtained without resorting to an action, by application to the Court of Chancery. Penalties, moreover, are imposed upon persons who without licence use the name, stamp, or mark of a patentee. An action or suit for infringement of patent may be successfully resisted, either on the ground that no infringement has in fact taken place, or that the patent is void; and such invalidity may be established either by showing that the article was not a fit subject for a patent, or that the patentee was not the first inventor, or that the specification was insufficient. Nor is this the only method of defeating claims founded on an illegal grant of patent right; for whether there be any complaint of infringement or not, it is competent to the Queen (or to any subject of the realm in the Queen's name, by leave of the attorney-general) to institute a proceeding called *scire facias*, for the formal impeachment of the patent; upon which, if the patent be found open to any of the objections above enumerated, or to any other sufficient legal exception, it will be cancelled.

For the protection of patentees, several other provisions of great importance have been enacted. First, in the case where, after a patent has been granted to a person believing himself to be the first inventor, it is discovered that some other person had in fact preceded him in the use of the invention, though the article was, at the time of the grant, not generally known to the public, the patentee or his assigns may petition Her Majesty in council for a new grant, or a confirmation of the existing one; and if the judicial committee of the privy council, upon investigation of the case, report in his favour, such petition may be granted. Again, if any error be discovered in the title or specification, the patentee or his assigns may rectify it for the future by filing in the proper office in chancery a *disclaimer* of any part of the title or specification, or a memorandum of any alteration therein that does not operate as an extension of the patent right.

The statutes relating to patents are the Statute of Monopolies above mentioned; and of more recent date, the 5 & 6 Will. IV., c. 83; 2 & 3 Vict., c. 67; 7 & 8 Vict., c. 69; 15 & 16 Vict., c. 83 (which introduced very great and very beneficial alterations in the proceedings relating to patents, and is styled "The Patent Law Amendment Act, 1852"); the 16 & 17 Vict., cc. 5 and 115; and lastly, the 22 Vict. c. 13, which provides for keeping secret in certain cases the particulars of inventions of instruments and munitions of war.

The fees payable upon the grant of a patent for the full term of fourteen years are about 175*l.*

See, upon the law of patents, Stephen's 'Commentaries,' vol. ii. p. 25, *et seq.*, where the statutory and case law is completely and succinctly collected.

See, upon the subject generally, and also upon "the Patent Office Museum and Library," a very valuable article in the 'Companion to the British Almanac,' for 1860.

PATENT. [Patterns.]

PATENT, LETTERS. [Letters-Patent.]

PA'TERA, an open vessel, approaching to the form of a cup but flatter, used by the Romans in their sacrifices, in which they received the blood of the victims, and with which they made libations. Some pateræ have a single handle. The word contains the same root as *pateo*: "Patera ut et ipsum nomen indicio est, poculum planum ac patens est." (Macrobius, 'Saturn,' v. 21.) Flat open vessels used by the Romans at their meals were called pateræ, whence perhaps pateræ came to be employed in offerings to the gods. Virgil, in several passages of the 'Æneid,' alludes to the uses of the patera. (Lib., vi. 248, iv. 60, vii. 133.)

On medals the patera is represented in the hands of several of the deities (Rasche, 'Lexicon Universalis Rei Numariæ,' tom. iii., part. ii., pp. 626, 627), and frequently in the hands of princes, to mark the sacerdotal authority as joined with regal power. The patera was of gold, silver, bronze, marble, glass, or earthenware. Such as had served for libations of wine or any other liquor at a funeral were usually deposited with the ashes of the deceased. Pateræ were often ornamented with engraved or embossed designs, and sometimes with gems. They appear to have been called by their prevalent mode of ornamentation, fern and ivy being the most usual, as patera filicata, patera hederata. The British Museum contains many fine specimens of fictile as well as bronze pateræ; also several sculptured marble votive pateræ, with figures of Pan, Silenus, Cupid, &c. Patella (that is, paterula) is the diminutive of patera.

The term *patera* is applied to a circular flat or concave ornament in classical architecture. It is also used for ornaments of a similar form in Italian and Gothic architecture.

PATERNITY. [Bastard.]

PATHOLOGY (from *πάθος*, 'disease,' and *λόγος*, 'a discourse') is the science of diseases, and especially of those which affect men and animals which are the subjects of medical treatment.

For the perfect knowledge of the nature of a disease, the first circumstance to be determined is its cause; and this is commonly regarded as twofold. The predisposing cause or condition (for the term cause cannot fairly be used in this sense) is that state of any individual which renders him peculiarly liable to the attack of any or of some particular disease, of which another person or he himself at another time might be in little danger. Of these predisposing conditions the most important is hereditary disposition, by which an individual being constructed with the same peculiarities of internal and of external form and composition, which one or both of his parents possessed, is liable to the same diseases as they were. Such are the peculiarities of temperament or constitution with which each individual is born, and by which he is through life disposed to a peculiar character of disease; and such also are the special hereditary dispositions to scrofula, gout, insanity, some forms of asthma, and probably many more diseases. Other predisposing conditions are the peculiarities of constitution which are acquired in the course of life by particular modes of living. Each individual is adapted by habit and other circumstances to the conditions of climate, &c. in which he is placed, and is peculiarly liable to be affected by changes of these external conditions. A person of effeminate habits living carefully secluded from all excitants of diseases, is much more liable to be affected by exposure to any of them than one whose frame by a hardy course of life is rendered comparatively invulnerable to all. Any means by which the strength of the body is reduced render it more liable to diseases of all kinds, and hence our idea of bodily strength is drawn not more from the muscular power of the individual than from his immunity from the effects of those circumstances which in others excite disease. There are also local peculiarities of individual organs of the body which render them especially liable to disease; such are the state bordering upon disease which is brought on by constant over-excitement of any organ; the condition of an organ which has once been affected with a disease, and which is commonly thenceforward particularly liable to a repetition of it; the state of the organs which at different periods of life renders one more than another liable to disease, so that the same excitant will be most likely to produce in the child an affection of the head, in the youth a disease of the chest, and in the adult or old person some disorder of the abdominal organs.

Any of these predispositions however may exist throughout life without the occurrence of actual disease; in order to produce disease, some more immediate or exciting cause is necessary. This excitant must be the more powerful the less the predisposition: but under whatever circumstances disease is produced, the predisposing condition of the patient may be expected to confer upon it a corresponding peculiarity of character. The exciting causes of diseases are any changes of a certain extent in the conditions of the external circumstances in which man is placed. For example, a certain range of external temperature, a certain constitution of the atmosphere, a certain supply of pure food and drink, a certain amount of mental and bodily exertion, are circumstances essential to health, and alterations in any of them may produce disease, of which the nature and the seat will be determined in part by the predisposition of each individual, and in part by the peculiar mode of action of the excitant. Thus, after the same exciting cause (for example, exposure to cold and damp), one person may have rheumatism, another pleurisy, a third ophthalmia, and a fourth may escape altogether unharmed. But there are other excitants of disease which prevail over all predisposition, and produce a certain character of disease, which the constitution of the patient can only slightly modify; such are the materials of all contagious and epidemic disorders, as influenza, small-pox, measles, &c., which produce in all whom they attack a similar affection. Many persons however escape from the effects of these excitants, and by long exposure become inured to them; hence the diseases of peculiar climates (endemics) affect foreigners much more than natives; but even in those persons in whom they do not produce disease, these conditions, which are excitants of disease in others, modify the characters of diseases that occur from any other source; and hence in the course of an epidemic all diseases have a tendency to assume some of the characters of that which is prevalent. Other excitants of disease, still more universal in their influence and more constant in their consequences, are all things which act immediately on the composition or construction of the body or of the blood, such as mechanical and chemical injuries, including poisons of all kinds.

The nature of a disease being determined by the condition of the individual and the exciting cause to which he is exposed, the next division of pathology is the study of the symptoms or signs by which the progress of a disease is marked, and by which in practice its nature is to be determined. Of these signs of disease, many are expressive of the altered condition of the part chiefly affected, as pain in a wound, or a local inflammation, coughing in a disease of the lungs, sickness in a disorder of the stomach: but a greater number are the expressions of an affection of other organs, which suffer in association with those primarily diseased; such are pain in the head when the digestion is disordered, coughing in diseases of the liver, sickness after violent blows on the head. Sometimes these secondary symptoms completely mask those immediately resulting from the primary disease; as when in a disease of the hip the chief pain is felt in the knee, or in hysteria any organ may appear disordered except that which actually is. These secondary symptoms are ascribed to what is called sympathy, an unsatisfactory expression indicating only the coincidence and probable connection of symptoms of disease in two organs, of which one only is supposed to be materially affected. Entire ignorance must be confessed of the nature and origin of many of these sympathetic or indirect symptoms of disease; as, for example, of the fever consequent on local injuries or acute local diseases, and of the hectic fever of many chronic affections; but it is probable that all sympathies will in time be found to depend either on some communication of excitement from one nerve to another through the medium of the spinal chord or brain, as in the reflex actions [Nervous system, in Nat. Hist. Div.], or on some change in the blood which affects both organs at once, or which, originating in the disease of one disturbs the functions of the other, or of the whole body.

Whether directly or indirectly produced, all the symptoms of disease are only the perversions of the natural functions of the part affected, or appreciable changes in its structure; their value and meaning therefore can only be determined by a comparison with the same functions and structure in health; in other words, this, like all other parts of pathology, cannot be rightly studied without a constant reference to physiology. It is believed that an organ may be only functionally deranged; that is, that its several functions may be performed in a very unhealthy manner, without the existence of any material change in its structure and composition. These are called functional symptoms, but their number is probably much less than is generally believed, and it is most likely that they are limited to the variations to which the organs are subject by the changes in the mode and measure of the influence of the nerves upon them. For all other symptoms we must assume the existence of a substantial change in the part affected, or in the materials on which it has to act, although in many cases these changes are fugacious or inappreciable by our senses.

For a due performance of all the functions of organic life [Vitality, in Nat. Hist. Div.], a healthy structure of each organ, and a healthy composition of the blood, on which they all act and all depend for their own maintenance, are alike necessary; a deviation from health in either will therefore produce the symptoms of disease; a conclusion, in which the long continued disputes of the humoral pathologists, who ascribed all disease to the blood, and the solidists, who held all to depend on changes of structure, have at length merged. To these two kinds of alterations, and to perturbations in the distribution of the nervous influence, it is probable that the signs of all diseases may be referred; but from the peculiar and complicated nature of the animal body, and the universal connection between all its organs, no one of these changes can long continue without producing the others; and hence in diseases of any degree of severity the symptoms are commonly a mixture of the disorders of all the functions of the body, and the disorder of each is modified by the changes in all those circumstances on which its healthy state depended, as the condition of the blood, of the nervous influence, &c. Neither are the symptoms in any case constant phenomena; for the influences of all external circumstances upon a diseased body are very different from those which they exert upon the healthy body, and many things which were necessary to health are supporters of disease, as the usual amount of food, of bodily and mental exertion, &c.; so that exclusion from them becomes necessary, and this again further modifies the performance of the disordered functions.

The history of a disease is completed by the process of natural recovery or by the observation of the changes in the structure of the body which it produces. The influence of remedies cannot justly be considered as a branch of pathology; though most important for their utility, still, in their relations to the natural history of a disease, medicines can only be regarded as interfering circumstances, or as the means of experiments for the determination of the relation of the diseased body to particular agents, by which the nature of the disorder affecting it may be sometimes ascertained.

The recovery from disease is an example of the exercise of that power by which the body can make unusual efforts to prevent its own destruction: this has been called the vis medicatrix naturæ, or curative force of nature. It is exerted in many cases in which disease cannot be said to exist, but where rather there is an exaggeration of health; as, for example, when a muscle subjected to unusual exertion and an unusually great amount of waste not only repairs its loss, but actually becomes larger and stronger, so that it can bear the same amount of constant waste better than at first; or as when a person is exposed for a time to cold in bathing, the speedy consequence is an increased warmth of the surface. The term reaction is applied to phenomena of this kind, and it may be said that reaction takes place whenever any injurious influence is applied to the body. In simple cases the reaction effects at once a restoration to health, as in the instances above mentioned; in others the reaction is itself the most prominent feature of the disease, as in fever and inflammation.

The recovery from disease is rarely perfect. Although no visible change may be left behind, yet the part diseased is commonly for ever after weak, that is, more than usually liable to the same or to some other disease. It is probable that this liability is owing to some morbid change in the structure of the part inappreciable by our present means of examination; in more distinct cases, when any part has been severely diseased, we never see a perfect restoration of its healthy structure and form. Even in those tissues that are most easily repaired, there is not an actual reproduction of the injured structure.

The period occupied in the progress of a disease to recovery or death is the basis of the chief division of acute and chronic diseases. The severity of the symptoms may in both cases be the same; but in general those of chronic cases are less prominent than those of acute cases.

When the disease terminates fatally, or when death takes place from any other cause at a distant period from its occurrence, we obtain perhaps the most valuable because the most certain part of pathological knowledge, that of the material effects which the morbid process has produced. This, the study of morbid anatomy, is often specially called pathology. By the examination of the altered parts and a comparison of the changes of structure which they present with those which are known by observation of external diseases or by experiment to result from certain leading morbid processes, as inflammation, &c., we are enabled to determine the nature of that which had existed beyond the limit of our senses, and thus to appreciate correctly the meaning of the several symptoms which had marked its progress during life, and the powers and modes of action of the circumstances to which it owes it origin. The practical value of such knowledge is the power which it affords of determining during life the nature of each disease, and the appropriate remedy for each.

PA'TINA, a shallow bowl, or basin, of earthenware, used by the Greeks and Romans for various domestic purposes, but chiefly in cooking or in serving at the table. Patinæ were sometimes made of bronze or silver. The eucharistic patena of the Romish Church is no doubt derived from it, though it differs in form. [Patena.]

PA'TINA, a word used by archæologists to express the polished rust by which ancient remains of copper, bronze, or brass are covered when laying in particular soils. This rust tends to the preservation of the object, and enhances its value, and appears to have been prized by the Greeks and Romans. The variety of tints of red, green, blue, brown, purple, olive, and yellow is owing to the combustion of oxygen, carbonic acid, and other gases with the alloys of which the metal is composed. [Numismatics.]

PATRIARCH (πατριάρχης, the head of a family), a title given to the heads of families in the early history of the human race, and more particularly to the ancestors of the people of Israel down to the time of Moses, and especially applied to the twelve sons of Jacob, as the ancestors of the twelve tribes of Israel.

There is a book in existence entitled 'The Testaments of the Twelve Patriarchs, the Sons of Jacob,' containing what profess to be the dying admonitions of the patriarchs to their children, and their predictions of the future fortunes of their descendants. This work has been published in Greek by Grabe, from manuscripts in the universities of Oxford and Cambridge ('Spicileg. Patr.,' tom. i.), and again by Fabricius ('Cod. Pseudepigr. Vet. Test.,' 1713); it was translated into Latin by Grostête, bishop of Lincoln (8vo, Haganoe, 1532), into French by Francis Mace, and into English by Whiston, in 'A Collection of Records belonging to the Old and New Testament,' London, 1727-8. Whiston has a dissertation to prove the authenticity of the work, but his arguments are neither worth repeating nor refuting. It is undoubtedly spurious. There is no evidence to prove that it ever existed in Hebrew, and the earliest reference to it by any ancient writer is one by Origen, who expressly asserts that it formed no part of the canon. Lardner has a very good notice of the work. ('Credibility,' pt. ii., ch. xxix., s. 3.)

The author of this book was probably a converted Jew, though not, as Cave supposed, a Judaising Christian. It seems to have been written about the end of the 2nd century.

Patriarch, in Church history, was also the ecclesiastical chief of a diocese, which included several provinces. It is not known at what time this title was introduced into the Church, but before the 4th century the bishops of Rome, Antioch, and Alexandria, had obtained a degree of pre-eminence over the other bishops. In the time of Constantine the Great the bishop of Constantinople was made to rank with the three just mentioned; and either then or not long after the title of patriarch was given to these four prelates. The number of these dignitaries was increased in the 5th century. The patriarch of Constantinople reduced under his jurisdiction those of Antioch and Alexandria, and obtained the title of "Universal Patriarch." The bishop of Rome was called "Prince of the Patriarchs." The struggle between the patriarchs of Rome and Constantinople for supremacy was the chief cause of the separation between the Eastern and Western Churches.

The powers of the patriarchs are thus described by Mosheim:—"They alone consecrated the bishops who lived in the provinces that belonged to their jurisdiction. They assembled yearly in council the clergy of their respective districts, in order to regulate the affairs of the Church. The cognisance of all important causes, and the determination of the more weighty controversies, were referred to the patriarch of the province where they arose. They also pronounced a decisive judgment in those cases where accusations were brought against bishops. And lastly, they appointed vicars, or deputies, clothed with their authority, for the preservation of order and tranquillity in the remoter provinces." (Mosheim, 'Ecc. Hist.' Cent. v., pt. ii., chap. 2.) There were, however, provinces of the empire which were exempt from their jurisdiction.

The Greek Church is at present governed by four patriarchs, namely, those of Constantinople, Jerusalem, Antioch, and Alexandria.

PATRICIANS (*Patres*, *Patricii*, in Latin) was the appellation of the members of the original houses or gentes, of which the Roman populus, the ruling power in the community, was at first composed, and of their descendants, either by blood or adoption. They were originally divided into three tribes, the Ramnes, Tities, and Luceres; each tribe into ten curiæ, and each curia into ten decuriæ, which Niebuhr has identified with the gens or house. The Luceres were admitted later to the rank, and were styled gentes minores, in opposition to the other two tribes, styled majores. Each house became subdivided into several familiæ, which were distinguished by a surname, in addition to the name of the gens, which was common to all, like that of the Scotch clan. Thus the gens Cornelia comprised the families of the Scipiones, the Lentuli, the Sullæ, &c. The families composing a gens were not necessarily related by consanguinity, for individuals might be adopted into a gens, and under the early Roman kings such admissions were frequent. The definition of a gens by Scaevola (Cic., 'Top.,' c. 6) is, that the members bore a common name, were descended from freemen, without any stain of slavery among their ancestors, and had never incurred any legal disability; they had common sacred rites, or sacrifices appointed for stated days and places. When a family became extinct by default of heirs in the male line, its property reverted to the gens of which it formed a part. Gentile and patrician were therefore synonymous. Freedmen and their descendants belonged to the gens of which they bore the name, but they had not the rights of the gens, that is to say, the gentile rights. Natives of the confederate towns of Latium coming to settle at Rome attached themselves to some gentile family, the head of which was styled their patron, and they were styled his clients. [Client.]

The members of the senate, the consuls, and the pontifices were, in the first ages of the republic, chosen exclusively from among the patricians, until the year 365 B.C., when Licinius carried his rogations, by which the plebeians were admitted to the consulship, as well as to the custody of the Sibylline or sacred books. [Licinius Stolo, in Biog. Div.]

When the plebeians became eligible to all the offices of the state, a new nobility was formed, consisting of those who had filled the offices of consul, prætor, or curule ædile, and this nobility was transmitted to their posterity with the "Jus imaginum," or the right of setting up in their houses the images of their ancestors. Still a distinction in opinion continued to prevail in favour of the patricians, or older nobility, as distinguished from the plebeian families.

When Constantine transferred the seat of the empire to his new city, he established there a new senate and a new patrician order, the members of which were appointed by the emperor. Their privileges consisted in being freed from certain taxes and jurisdictions, and wearing the chlamys and calceus. After the fall of the Western Empire, the officers sent by the Byzantine emperors to administer the provinces of Italy subject to them, were chosen from among the patricians of

Constantinople. Thus we read in the history of the dark ages, of the "patrician of Rome," meaning the governor or representative of the Eastern emperor in that city, and the title was afterwards assumed by Charlemagne and his successors.

At Venice the title of patrician was given to the members of the great council, or supreme legislature, and their descendants, and their names were registered in the golden book. After the decree of February, 1297, called "La serrata del maggior consiglio,' no new member was introduced into the council, but all the descendants of those who had once sat in the great council, on arriving at twenty-five years of age, were by right members of the sovereign assembly, and patricians of Venice. "Patrizio Veneto" was a title of nobility, considered equal to that of any feudal noble not of a sovereign house.

In other parts of Italy, such as Genoa and Rome, the word patrician was and is still used in common language to denote a member of the hereditary nobility, independently of any feudal title.

PATRISTIC THEOLOGY. [THEOLOGY.]

PATRON. [BENEFICE; PARISH.]

PATRO'NUS, derived from *pater*, a "father," as *materna* is formed from *mater*, a "mother." The relation of Patron and Client (*cliens*) in ancient Rome is discussed in the article CLIENT; but the relation between a freedman (*libertus*) and his patronus requires a few words of explanation.

In the Roman polity persons were divided, with respect to status or condition, into freemen (*liberi*) and slaves (*servi*). Freemen were again divided into persons who were born in a state of freedom (*ingenui*), and those who had been manumitted (*libertini*). A manumitted slave was called *libertus*, that is, *liberatus*, "freed," and his master who manumitted him became his *patronus*. The slave who was manumitted received the gentile name of his patronus. (See Lactant. 'Div. Instit.' iv. 3.; Plin. 'Hist. Nat.' xxv. 3, and xxxi. 3; Pers. 'Sat.' v. 78.) The relation between patronus and libertus resembled in many respects that between patronus and cliens; but it appears that their mutual rights and obligations were rather regulated by public opinion than fixed by any positive enactment. The patronus on the one hand was bound to take the libertus under his protection; and the libertus on his part was bound to assist his patronus by every means in his power, but the only case in which he was compelled by the law to do so, was when the patronus or his children had become too poor to support themselves. In such a case, if the patronus or his children proved to the satisfaction of the governor of the province (*præses*) their necessitous condition, he might direct the libertus to allow a monthly payment for their support (D. 25. 3. 9).

The most important part however of the connection between the patronus and the libertus was the right which the former had in certain cases to the property or a portion of the property of the latter upon his death. This right was founded upon the fact, that the law regarded patroni as the adgnati of their liberti, and consequently they succeeded to the property like any other adgnati. By a law of the Twelve Tables, if the libertus died intestate and left no heir (*suus heres*), the patronus succeeded to his property. (Gaii. 'Comm.' iii. 40; Justin. 'Inst.' iii. 8. 1.) If the heir was a son born of his own body (*naturalis*), no one had a right to complain; but it appeared to the Romans a great injustice that an adopted son or daughter, or a wife (*in manu*), should deprive the patron of his right to the property. This injustice was remedied by the prætor's edict, which enacted that the patron's right should be barred only by the libertus leaving natural sons, whether under his power at the time of his death, or sui juris, or adopted by another during his life, provided they had not been disinherited, and that if a libertus who had no natural sons made a will, he should be obliged to leave half of his property to his patronus; and if he left none of his property, or less than half, the bonorum possessio of half should be given to the patronus, even against the words of the will; if the libertus died intestate, leaving an adopted son, a wife (*in manu*), or a daughter-in-law (*in manu filii ejus*), half of the property was also given to the patronus. ('Gaius,' iii. 40, 41; 'Institut.,' iii. 8. 1.)

By the Lex Papia the rights of patrons to the property of their rich freedmen were still further increased. By this law it was enacted, that if a libertus died leaving property to the value of 100,000 sesterces, a portion of his property (*virilis pars*) went to his patronus, whether he had made a will or died intestate, provided he had fewer than three children. If he left only one son or one daughter, half of his property went to his patronus, as if he had died leaving no son or daughter; if he left two children, a third went to the patronus, but if three, the patronus had no claim to any portion. (Gaius iii. 42; Institut.,' iii. 8. 2.)

With regard however to the property of a liberta, the ancient law sufficiently protected the rights of the patronus, and he therefore had no occasion to have recourse to the edict of the prætor. For since the patronus was the tutor of the liberta, she could not make a will without his consent, and consequently could not leave her property to any one else. (Gaius, iii. 43; Ulp., 'Fr.' xxix. 2.) The Lex Papia however set free a liberta who had brought forth four children from the tutela of her patronus. (Gaius iii. 44; Ulp., 'Fr.' xxix. 3.)

The patrona, previous to the passing of the Lex Papia, had no greater right to the property of the libertus than was granted to the patronus by the Twelve Tables, and could not, like the patronus, obtain by the prætor's edict the half of the property of a libertus who had left only an adopted son or a wife or daughter-in-law. By the Lex Papia, however, an ingenua patrona, who had brought forth two children, and a libertina patrona, who had brought forth three, obtained almost the same rights as the patronus possessed by the prætor's edict; and an ingenua patrona who had brought forth three children obtained the same privileges as were given to the patronus by that law; but a libertina patrona in no case obtained the rights granted to the patronus by the same law. (Gaius, iii. 49, 50; Ulp., 'Fr.' xxix. 5, 6.)

The rights of a patronus to the property of a libertus only extended to his direct heredes, sons, grandsons, great-grandsons, &c., and never belonged to his collateral heirs (*extranei heredes*). (Gaius, iii. 58.) A patronus was able to assign a libertus (*adsignare libertum*) to one of his sons to the exclusion of his other children, so that on the death of a libertus, the son to whom the libertus had been assigned was alone entitled to the property, which was due to the patronus by the jus patronatus. ('Institut.,' iii., tit. 9; 'Dig.,' 50. 16. 107.)

All the preceding remarks respecting the succession of the patronus to the property of the libertus, only apply to the property of those liberti who were Roman citizens. Those liberti who were Latini [LATINUM JUS], or Dediticii, had in fact no power over the disposal of their property. The Latini liberti had the privileges of freemen while alive, but "they lost their life and their liberty at the same time," and their property, like the *peculia* of slaves, came by the Lex Junia to the persons who had manumitted them (Gaius., iii., 56; 'Institut.,' iii. 8.4.) The succession to the property of the liberti Latini differed also in many other important particulars, which Gaius has pointed out (iii. 57-62), from the succession to the property of those liberti who were Roman citizens. By a decree of the senate passed in the reign of Claudius during the consulship of Lupus and Largus, it was enacted that the property of the Latini should pass first to those who had manumitted them and their children not disinherited by name, and afterwards to their other heirs. (Gaius, iii. 63; 'Institut.,' iii. 8.4.) By a constitutio of Trajan, it was enacted that if a Latin libertus obtained from the Emperor the jus Quiritium without the knowledge or against the will of his patronus, he should enjoy the privileges of a Roman citizen while he lived, but should be regarded as a Latinus at the time of his death, and should have no power of leaving his children as his heredes; and that he should only be allowed to make a will so far as to leave his patronus his heir, or if the latter were unwilling to become his heir, of substituting another in his place. (Gaius, iii. 72.) This constitutio however was a little altered by one of Hadrian, who gave with certain conditions the same privileges to those Latini who had obtained the jus Quiritium from the Emperor, as to those who had obtained it by a decree of the senate or the Lex Ælia Sentia. (Gaius, iii. 73.)

These laws were however very much altered by Justinian. He gave to the liberti Latini and Dediticii the same privileges as those liberti possessed who were Roman citizens. He also enacted, that if a libertus or liberta left less property than amounted to the value of 100 aurei, the patronus had no claim to any portion of the property, provided they made a will; but if they died intestate, leaving no children, then the patronus succeeded to the property by the law of the Twelve Tables. If the property of the libertus or liberta was of more value than 100 aurei, and they left children, the patronus had also no claim to any part of the property; but if those liberti or libertæ who left no children died intestate, the patronus succeeded to the whole of the property, and if they made a will without leaving any part of their property to the patronus, then he had a right to a third of the property, and not to a half, as was formerly the case. ('Instit.,' iii. 8.3.)

(Gaius, iii. 39-76; Ulpian, *Fragm.*, xxvii. 1-5; xxviii. 7; xxix. 1-7; *Institutiones*, iii., tit. 8, *De Successione Libertorum*; tit. 9, *De Adsignatione Libertorum:* Digest. 37, tit. 14, *De Jure Patronatus*; 38, tit. 2, *De Bonis Libertorum;* 38, tit. 4, *De Adsignandis Libertis; Collatio Legum Mosaic. et Roman.*, xvi, 8, 9; Unterholzner, *Ueber das patronatische Erbrecht*, in the *Zeitschrift für Geschichtliche Rechtswissenschaft*, 5th vol., 1st part, Berlin, 1823; and the articles CLIENT, LATINUM JUS, and LIBERTINUS, in this work.)

PATRO'NYMIC (πατρωνυμικὸς) is a name given by grammarians to those words which express the name of a person's father or ancestor. Thus Achilles is called Pelides (the son of Peleus), Agamemnon is styled Atrides (the son of Atreus), &c. In the English language we have no words of this description, but in Sanscrit and Greek they are very common, especially in Sanscrit, which has as many as thirteen different terminations to form such words, namely, *a, aki, âyana, âyani, âyanya, inêya, irya, êya, êra, aira, kâyani, ki, ya*. In Greek the most common masculine termination is *ides*, as *Cecrop-ides*, a descendant of Cecrops; some patronymics are formed by adding *ion*, as *Kron-ion*, the son of *Kronos*, &c. Feminine patronymics in Greek are commonly formed by adding *id* (in the nominative *is*), as *Tantal-is*, gen. *Tantal-id-os*, the daughter of Tantalus. In Lithuanian some patronymics are formed by adding *na*, as *Janow-na*, the son of Janow or John (Pott's 'Etymologische Forschungen,' vol. ii., p. 579); which termination may perhaps be connected with the Latin *an-us*, which forms such patronymics as *Octavi-anus*, one of the family of Octavius, *Æmili-anus*, one of the family of Æmilius, &c. In English, though not very correctly, the surname is often styled the patronymic.

PATTERNS. Connected with the subject of patents is the copyright of designs. By recent Acts of Parliament (5 & 6 Vict. c. 100; 6 & 7 Vict. c. 65; and 13 & 14 Vict. c. 104—known respectively as "The Designs Act, 1842;" "The Designs Act, 1843;" and "The Designs Act, 1850"), the inventor, or purchaser, or proprietor of any new design for ornamenting any article of manufacture of a useful character in respect of the pattern, or the shape, or the external appearance, may register such design, and thereby secure the sole right of applying it for a period of three years, subject to extension at the discretion of the Board of Trade.

Provision is contained in the later Act for provisional registration for one year.

The person intending to register must take or send to the office of the Registry of Designs, 1, Whitehall, two copies or drawings of his design; one of which will be filed by the registrar, and the other returned to the party registering, with a certificate, which certificate is made evidence of registration.

Every article manufactured according to such design must have thereon the number of the design in the register, and the date of the registration.

Any person pirating a design thus protected is liable to a penalty of from 5*l.* to 30*l.* for each offence, which may be recovered by an action at law, or by summary proceeding before two magistrates.

Registered designs may be transferred from one person to another, in which case the latter is entitled to be registered as the proprietor. Printed forms of such transfers are supplied at the office.

The commissioners of the Treasury have power to fix the fees payable upon registrations, transfers, &c. These fees are of very moderate amount.

PAUPERISM. [POOR LAWS.]

PAUSE. [ORATORY; PUNCTUATION.]

PAVEMENT. [ROADS.]

PAVIIN. A crystallisable substance found by Professor Stokes in the bark of the horse-chestnut. It is remarkable for exhibiting a beautiful bluish-green fluorescence when placed in violet light. It is supposed to be identical with *fraxin*.

PAVING. [ROADS.]

* **PAVO** (the Peacock), a constellation of Bayer, which occupies a part of the space situated between Sagittarius and the South Pole. Its principal stars are as follows:—

Character. (None in Bayer.)	No. in Catalogue of Lacaille.	No. in Catalogue of British Association.	Magnitude.
ζ	1525	6315	4
ε	1615	6801	4
δ	1635	6873	4

PAWN. [PLEDGE.]

PAWNBROKERS. All persons who receive goods by way of pawn or pledge for the repayment of money lent thereon at a higher rate of interest than five per cent. per annum, are pawnbrokers. The character of the individual to whom the money is lent is scarcely a subject of consideration with the lender; he may be satisfied, if he believe that the articles pledged are not stolen or come by in an unlawful manner.

Pawning differs from other ways of lending and borrowing money in this, that the goods of the borrower are delivered to the lender as a security. [PLEDGE.] Otherwise, when the lender has confidence in the integrity and solvency of the borrower, he is often satisfied with a written engagement from the borrower, and if it should be required, with the additional engagement of some other person. When further security is required by the lender, it may be land, or shares in a ship, or it may be something which is not in its nature capable of immediate tradition, as the future benefit to accrue from a policy of insurance; but all these kinds of security are different from that given in pawning, and are treated under the articles MORTGAGE and SHIPS.

The business of lending money on pledges is in many countries carried on under the immediate control of the government as a branch of the public administration; and where only private individuals engage in it, as in this country, it is placed under regulations. Thus in China, where pawnbrokers are very numerous, Sir J. F. Davis, in his work on the 'Chinese,' says "they are under strict regulations, and any one acting without a licence is liable to severe punishment. The usual period allowed for the redemption of the pawned goods is three years. The highest legal rate of interest on deposits is three per cent. per month; but in the winter months the money advanced on wearing apparel may not exceed two per cent., on the alleged ground that poor persons may be able the more easily to redeem."

During the existence of the Usury Laws in this country, which fixed the maximum legal rate of interest at five per cent. per annum, a higher rate was nevertheless chargeable by pawnbrokers under the section of the 39 & 40 Geo. 3, c. 99, an act which is still in force, and which regulates the various rates of interest on goods or chattels pawned according to the following scale:—

For every pledge upon which there shall have been lent any sum not exceeding 2*s.* 6*d.*, the sum of ½*d.*, for any time during which the said pledge shall remain in pawn not exceeding one calendar month, and the same for every calendar month afterwards, including the current month in which such pledge shall be redeemed, although such month shall not be expired. If there shall have been lent the sum of 5*s.*, one penny; 7*s.* 6*d.*, one penny halfpenny; 10*s.*, two-pence; 12*s.* 6*d.*, two-pence halfpenny; 15*s.*, three-pence; 17*s.* 6*d.*, three-pence halfpenny; 20*s.*, four-pence; and so on progressively and in proportion for any sum not exceeding forty shillings; but if exceeding 40*s.* and not exceeding 42*s.*, eight-pence; if exceeding 42*s.*, and not exceeding 10*l.*, after the rate of three-pence for every 20*s.*, by the calendar month, including the current month, and so on in proportion for any fractional sum. Parties may redeem goods within seven days after the expiration of the first calendar month without paying interest for the extra seven days; or within fourteen days on paying for one month and a half; after which time interest is charged for two calendar months. But in case the interest has accumulated throughout a series of months, the pawnbroker is not entitled to calculate it for a single month, taking advantage of an indivisible fraction, and then multiply the result by the number of months. The calculation in the first instance should be for the whole time at the rate allowed by law so as to avoid the injustice done the pawnor by the other method.

Pawnbrokers are required by the Act to keep books in which all goods taken in pledge must be entered and described, the sum advanced upon them, and the name and abode of the pledger, and whether he is a housekeeper or a lodger. They make out at the time two memoranda of these particulars, one of which is given to the pledger. For this duplicate, when under 10*s.*, one halfpenny is charged; 10*s.* and under 20*s.*, one penny; 1*l.* and under 5*l.*, twopence; 5*l.* and upwards, fourpence. Articles pledged for sums above 5*s.* must be entered in the pawnbroker's books within four hours; and those on which 10*s.* or upwards have been advanced must be entered in a separate book and numbered, the first entry in each month commencing No. 1. The number and description of the pledge in the books and on the duplicate correspond with each other. Articles cannot be taken out of pawn without the production of the duplicate, the holder of which is presumed to be the owner; but the original pawnor has a perfect right to sell the duplicate, and the pawnbroker is obliged to deliver the goods to the purchaser on the production of the duplicate with the principal and interest due on the pledge. If a duplicate be lost or stolen, the pawnbroker is required to give a copy of it to the party representing himself as the owner of the articles pledged, with a blank form of affidavit, which must be filled up with a statement of the circumstances under which the original duplicate was lost, and sworn before a magistrate. For this second duplicate the pawnbroker is entitled to demand one halfpenny, if the sum advanced does not exceed 5*s.*; from 5*s.* to 10*s.*, one penny; and afterwards in the same proportion as for the original duplicate.

The penalty against unlawfully pawning goods the property of others is between 20*s.* and 5*l.*, besides the full value of the goods pledged; and in default of payment, the offending party may be committed for three months' imprisonment and hard labour. Persons forging or counterfeiting duplicates, or not being able to give a good account of themselves on offering to pawn goods, are liable to imprisonment for any period not exceeding three months. Pawnbrokers or other persons buying or taking in pledge unfinished goods, linen, or apparel entrusted to others to wash or mend, are to forfeit double the sum advanced and to restore the goods. The Act empowers police-officers to search pawnbrokers' houses or warehouses when suspected to contain unfinished goods unlawfully pledged, and goods unlawfully pawned must be restored to the owner by the pawnbroker. Goods that have been stolen and pawned may be ordered by the judge or magistrate before whom the thief is convicted to be restored to the real owner; and without proceedings against the thief they may be recovered by the owner in an action at law against the pawnbroker.

All pawned goods are deemed forfeited at the end of one year. If redeemed, the pawnbroker must endorse on his duplicate the charge for interest, and keep it in his possession for one year. Articles on which sums have been advanced of 10*s.* and not exceeding 10*l.*, if not redeemed, must be sold by auction, after being exposed to public view and at least two days' notice having been given of the sale. The catalogue of sale must contain the name and abode of the pawnbroker, the month the goods were received, and their number as entered in the books and on the duplicate. Pictures, prints, books, bronzes, statues, busts, carvings in ivory and marble, cameos, intaglios, musical, mathematical, and philosophical instruments, and china, must be sold separate from other goods, on the first Monday in January, April, July, and October in every year. On notice not to sell given in writing, or in the presence of one witness, from persons having goods in pledge, three months further are allowed beyond the year for redemption; and if the owner tender principal and interest and demand delivery of the goods any time before sale, the pawnbroker is not afterwards entitled to sell them. But in the fact of selling unredeemed pledges there is no further warranty implied by law on the part of the pawnbroker than that the goods are unredeemed pledges, and that he is not cognisant of any defect of title attaching to them. An account of sales of pledges above 10*s.* must be entered in a book kept by the pawnbroker, and if articles are sold for more than the sum for which they were pledged, with interest thereon, the owner is entitled to the surplus, if demanded within three years after the sale. Pawnbrokers' sale-books are open to inspection on payment of a fee of one penny. The penalty on pawnbrokers' selling goods before the proper time, or injuring or losing them, and not making compensation to the owner, according to the award of a magistrate, is 10*l*. They are required to produce their books on the order of a magistrate in any dispute concerning pledges, and are not to purchase goods which are in their custody. The Act extends to the executors of pawnbrokers.

The Act prohibits pledges being taken from persons intoxicated or under twelve years of age. (By the 'Metropolitan' Police Act (2 & 3 Vict., c. 47), a fine of 5*l*. is inflicted upon pawnbrokers taking pledges from persons under the age of sixteen.) Pawnbrokers are prohibited from buying goods between the hours of 8 A.M. and 7 P.M.; and by the 9 & 10 Vict., c. 98 from receiving pledges between Michaelmas-day and Lady-day before 8 A.M. or after 7 P.M.; and for the remainder of the year, before 7 A.M. or after 8 P.M., excepting on Saturdays and the evenings preceding Good Friday and Christmas Day, or any public fast or thanksgiving day appointed by the Crown, when the hour for closing is extended to 11 P.M. They are required to place a table of profits and charges in a conspicuous part of their places of business.

Pawnbrokers are required to take out an annual licence from the Stamp-Office; and, to enable them to take in pledge articles of gold and silver, a second licence is necessary, which costs 5*l*. 15*s*. Those who carry on business within the limits of the old Twopenny Post pay 15*l*. a-year for their licence, and in other parts of Great Britain 7*l*. 10*s*. The licence expires on the 31st July, and a penalty of 50*l*. is incurred if it is not renewed ten days before. No licence is required in Ireland, but those who carry on the business of a pawnbroker must be registered. Any one who enters into secret partnership with a pawnbroker for the purpose of carrying on that business, even although the agreement stipulates only for a right to inspect the books and to receive a per centage on the business done, renders himself liable to penalties under the statute. But to repress the practice of laying frivolous and unfounded informations against this class of tradesmen, the 2 & 3 Vict. c. 71, ss. 32-35, giving power to magistrates to award amends in such cases, to inflict penalties on common informers who compound informations, to diminish the amount of the portion awarded of the penalty to any informer, and further to diminish the term of imprisonment fixed in the case of offenders, is extended by the 22 & 23 Vict. c. 14 to the 39 & 40 Geo. 3, c. 99, and to all parts of England, and to all magistrates, justices, or justices of the peace.

The act for the regulation of pawnbrokers in Ireland is the 28 Geo. III., c. 43 (Irish statute). It requires pawnbrokers to take out licences and to give securities; appoints the marshal of the city of Dublin corporation registrar of licences; directs returns to be made to him monthly, upon oath, of sums lent; and allows the registrar a fee of one shilling on each return. The Act requires the returns to be laid before parliament; but this is not done, and in some other particulars the statute is but imperfectly observed.

PAX, an ecclesiastical instrument of ancient use in the Roman Catholic church. St. Paul, in several of his epistles, commands the professors of the Christian religion to "salute each other with a holy kiss." That this was literally practised in the first ages of the church, we learn from the apostolical constitutions, together with some particulars respecting the method of performing this ceremony. "Let the bishop salute the church, and say, *The peace of God be with you all*: and let the people answer, *And with* thy *spirit*. Then let the deacon say to all, *Salute one another with a holy kiss*, and let the clergy kiss the bishop, and the laymen the laymen, and the women the women." (Li. viii., c. 11, apud Coteller, p. 345.)

The custom of giving the kiss of peace before the communion, in the more solemn service of the Roman Catholic Church called the High Mass, is still kept up among the officiating clergy, as well as among the men and women of the different religious orders. So also it appears to have been practised by the laity during the middle ages; while the men and women were separated from each other. But when the sexes began to be mixed together in the less solemn service called the Low Mass, which began to take place in the 12th or 13th century, a sense of decorum dictated to the bishops the use of an instrument called sometimes a *Pax*, sometimes *Tabula Pacis*, and sometimes *Osculatorium*, which the priest kissed first, then the clerk, and lastly the people who assisted at the service, one after another, instead of the former kiss.

Among the constitutions of Walter de Grey, archbishop of York in 1250, an osculatorium was one of the regular ecclesiastical ornaments, or rather implements, ordered to be provided in every parish church.

It was usually in the form of a metallic plate or tablet, with a support at the back, and had a representation of the crucifixion in front, either in relief or engraved. The magnificent pax of silver, engraved in niello, by Finiguerra, is still preserved at Florence. In the South Kensington Museum is a remarkably fine pax of Italian work of near the close of the 15th century. The central plate is of bronze, on which is a representation in relief, attributed to Botticelli, of the Virgin under a canopy, surrounded by angels. This is set in a gilt mounting, enriched with silver filagree work; while the support is ornamented with three small niello plates. Many others are extant, which are admirable examples of the metallic art of the time.

The general disuse of this plate in modern times is attributed by Le Brun ('Explication Litterale, &c., de la Messe,' tom. i., p. 595) to certain jealousies which were found to arise among individuals, about priority in having it presented to them.

The use of the Pax was not among the ceremonies which were first abrogated at the Reformation in England: on the contrary, it was enforced by the ecclesiastical commissioners of Edward VI., and rendered more ostensible than it had been, as appears by the following injunction, published in the deanery of Doncaster, in 1548:—"The clerk shall bring down the paxe, and standing without the church-door, shall say loudly to the people these words: 'This is the token of joyful peace, which is between God and man's conscience,'" &c.

PAYMENT. If a man owes several sums of money to another on different accounts, and makes a payment of any one of such sums, he may state at the time of payment on which account such sum is paid, and the payment will be considered to be legally appropriated to the debt which he has named. If at the time of payment the debtor makes no appropriation of the payment, the creditor may at the time of payment appropriate it to such debt as he pleases, provided he so appropriates the payment, as he would do, or as it may be presumed that he would do, if he were the debtor. Accordingly the creditor must appropriate the payment to such debt as is the most burdensome to the debtor. If neither party make any appropriation of the debt at the time of payment, the payment will be presumed to be made on account of the more burdensome debt; if there is no difference in the quality of the debts, the payment must be presumed to be made on account of the oldest.

These are the rules of the Roman Law ('Dig.' 46, tit. 3), which perhaps may be considered to be adopted by the English Law, though the decisions are by no means uniform in this matter. (Devaynes *v*. Noble, 1 Mer. 606.) The principles just laid down apply to distinct debts on different accounts (causae). If there are dealings between two persons which are all of one uniform and continuous nature, as for instance between a banker and his customer, there is no question of appropriation of payment. The customer pays money into the bank at different times, and draws it out by drafts at different times. All the sums paid in and all the sums paid out severally make an entire creditor and debtor account, and by striking the balance at any given time it will appear what sum is due at that time from the banker to his customer or from the customer to his banker. It is true that this supposes a kind of appropriation, but not exactly that kind which is meant by the term. It assumes that the sum first paid in is discharged by the sum first paid out, so far as it is sufficient to discharge it; and the same remark applies to all subsequent payments into the bank and sums drawn out. The account therefore must be made out in the order of time, and the balance will show how the account stands at the time when it is made ont. (Devaynes *v*. Noble.)

A debt barred by the Statute of Limitations cannot be revived by an appropriation of a general payment.

There are various other cases in the reports in which the question of appropriation of payments has been discussed. (Croft *v*. Lumley, 6 H. of L. Cas. 672; Beale *v*. Caddick, 2 H. & N. 326; Nash *v*. Hodgson, L. J. 25, Ch. 186; and Farley *v*. Turner, L. J. 26, Ch. 710.)

PEA. The garden pea (*Pisum sativum*) is a native of the south of Europe, but sufficiently hardy in a young state, or when its development is not much extended, to bear our winters when they are moderate, and when the plants have, as in gardens generally, a sheltered situation.

The pea had probably been introduced into this country at an early period, for peas are mentioned by Lydgate, in the time of Henry VI., as being hawked in London. It appears however that for nearly a century afterwards, they were either not very common, or the manner of obtaining them early was unknown, for Fuller states that in the reign of Elizabeth peas were brought from Holland, and were accounted "fit dainties for ladies, they came so far and cost so dear."

The varieties of the pea are numerous. Every seedsman issues a trustworthy list, from which selection is to be made according to the date of sowing.

The soil for peas ought to be fresh and well stirred, but not too rich; for in the latter case a luxuriant growth is induced without fertility.

The times of sowing are, in November for the earliest crop, and at intervals of a month, three weeks, or a fortnight, as the season advances, till Midsummer. The produce from any that may be sown after this period is very uncertain; as is indeed the case with the November and other sowings previous to those of spring. The shelter afforded the young plants in winter by spruce branches or temporary awnings is of course beneficial.

The distance which should be allotted for the intervals between the rows of peas may be three, four, five, or six feet, according to the growth of the sort and richness of the soil. The plants should not be allowed to grow too thick in the rows, otherwise they are drawn up slender, without a due proportion of foliage on the lower part of the stem, which, in that case, as well as the leaves depending on it, is apt to become unhealthy and to mildew.

Agricultural Cultivation.—The common pea is cultivated in the garden and in the field, and there are several varieties of it. The plant is naturally a creeper, having numerous tendrils, by which it lays hold of stronger plants and supports itself. The pods contain one row of round seeds, which at first are soft and juicy, in which state they are used for the table under the name of green peas. They afterwards harden and become farinaceous, and the stem dries up. In this state they are thrashed and stored for use like corn, and serve chiefly to fatten hogs. The straw is given to cattle and sheep in winter.

There are some varieties of peas the stems of which do not rise or creep, but remain short, and hence are called dwarf peas. These are preferred for early sowing in the garden, and likewise when they are cultivated in the fields to be gathered in a green state. Every gardener strives to raise early peas, and the first which are brought to the London market are sold for a very great price. As soon as they are more common, such quantities are sometimes raised in the fields, that the price scarcely defrays the expense of gathering and bringing to market. When the market is not overstocked, this crop is very profitable, as it does not exhaust the land, and there is good time for a crop of tares or turnips after the peas in the same season. But the usual purpose for which peas are cultivated in the regular course of husbandry, is to fatten sheep and hogs. A white sort, which readily splits when subjected to the action of millstones set wide apart so as not to grind them, is used in considerable quantities for soups, and especially for sea stores. There is also a blue sort which answers the same purpose. The hog pea is of a gray or dun colour.

Peas contain much farinaceous and saccharine matter, and are therefore highly nutritious; no other seed surpasses them in this quality, except the seed of the French bean (Phaseolus). But this is refused by most animals in the raw state, owing to a certain toughness, which makes them adhere to the teeth; and, even when boiled, they are not relished by them.

As food for hard-working men, peas are excellent when well boiled and mixed with some animal fat. In some countries peas-meal is baked into hard cakes, with or without oatmeal or barley-meal. These cakes are nutritious, but are of difficult digestion, except where custom and hard labour have inured the stomach to their use.

The soil best suited to the growth of peas is a light or sandy loam of some depth, and in good heart; the usual preparation of it is by repeated deep ploughing and pulverising with harrows or other instruments. It is not advisable to manure the land immediately for peas, as it makes them throw out abundant stems at the expense of the produce in pods. They follow well after barley in which no clover has been sown, and are a good substitute for clover where there would be a danger from the too frequent repetition of clover on the same land. When clover has failed, peas supply its place, the ground being ploughed up before winter, or early in spring, and well pulverised. The wheat is not generally so good after peas as after clover, when the clover is a good crop; but it is well known that if the clover fails, the wheat will also suffer. It is therefore better to have peas than to risk sowing wheat after a thin crop of clover. If the peas are not well hoed, and do not cover the surface, the land will be full of weeds; but with good management it may be looked upon as a cleansing crop. Many farmers consider peas as a very uncertain crop: but they are only so when the land is carelessly cultivated. They are, no doubt, often injured by want of moisture in the soil, or by an excess of it; but deep ploughing will prevent the former, and careful draining the latter. If peas are sown on land which is exhausted, or naturally very poor, no certain crop can be relied on. It sometimes happens however that an excellent crop is obtained against all probability, considering the state and tillage of the land, owing to some fortunate coincidences of favourable weather; and in this case it would appear as if great care in the preparation of the soil were unnecessary; but this is not often the case, and no prudent farmer will trust to the chances, which are much against success. In nine cases out of ten a slovenly cultivation or an improper succession of crops is the cause of great disappointment and loss, and it may be laid down as a general rule, that no good farmer will trust to accident, when by a little care and attention and a reasonable expenditure he may almost ensure success.

Peas must not be repeated on the same land in less than 10 or 12 years, nor are they to be recommended on very stiff clays, on which beans are to be preferred. Wherever beans suit the soil, they are a much better preparation for wheat than peas, admitting of much more frequent and perfect hoeing, besides the application of an abundant coat of dung, of which the wheat reaps the benefit as well as the beans.

Peas should be sown as early as the ground will admit of being worked; and in very mild winters January is a very good time for sowing peas, which are intended to be gathered green, in a sheltered situation sloping towards the south-west. The hog peas may be sown in February or March; and if they are horse-hoed, and the earth is raised against the young plants, they will not suffer from a moderate frost. When peas are drilled at two feet or more between the rows, it will not take above two bushels to drill an acre. The old method of sowing peas broadcast and ploughing them in is now seldom practised, and to sow them and harrow them in is nowhere recommended; the birds in this case having much too great a share of the seed. When peas follow clover, the practice of dibbling them into the sward, which has been turned over with the plough, is much to be preferred. Wherever dibbling is generally practised, and there are sufficient hands to put the seed into the ground in a reasonable time, it should be preferred for every kind of crop that can admit of the hoe in the intervals.

When peas are sown later than usual, it is useful to steep the seed a few hours, in order that it may vegetate the sooner. A week may often be gained in the coming up of the crop by this means.

The Everlasting Pea, which is so well known in our gardens, has been recommended to be cultivated in the fields for green fodder for horses, which are said to eat it readily. In land which has been well manured, it will produce a very great weight of green food; and there are probably varieties of it more succulent and sweeter than others. If it could be established in a field, it would produce abundant food for several years in succession, without any other cultivation than hoeing out the weeds and stirring the soil around the plants. The seed should be sown in rows, and the plants thinned out by the hoe, so as to stand a foot or 15 inches apart; they would then have room to grow out, and would cover the ground completely. By transplanting year-old plants, a still greater crop might be obtained. It is at least worth a trial.

Peas should be drilled in rows at such a distance as to admit the horse-hoe between them. They should be horse-hoed repeatedly until the stems are so long as to fall down and cover the intervals: a slight earthing of the rows with a plough has the effect of keeping the stems from the ground and allowing the air to circulate under them, by which the podding is much encouraged; for in wet seasons the stems are apt to lie on the wet ground and to rot. When the seed is ripe in the pods on the lower part of the stalks, the crop should be reaped, or many of the pods will burst, and the seed be lost. The reaping is performed by pulling the straw from the root by hand, or by means of two reaping-hooks, which partly tear up the stems, and partly cut them off. They are then gathered into small loose heaps, and left to dry. After being turned over till they are quite dry, they are carted to the stack or barn. Unless the quantity be considerable, so as to make a large stack, it is advisable to put them in a barn. When the peas are stacked, many of the pods are necessarily exposed to the depredation of birds; and, if they escape this, they burst, and the seed is lost.

The produce of an acre of good peas is from 30 to 40 bushels, and the price about the same as that of beans. They are consequently a profitable crop, and will well repay a little attention in the cultivation. If the land is not in sufficient order and heart to make it advisable to sow wheat after the peas, barley or oats may be advantageously substituted. If the peas fail, it may be necessary to clean the land with a fallow crop before any other corn is sown, for a bad crop of peas invariably leaves the land foul.

The straw or haulm of peas, when well harvested, makes excellent fodder for cattle, and especially for sheep, which are very fond of the dry pods when the seeds have been thrashed out.

In some places, they sow peas and beans together broadcast, and plough them in; the beans serve as a support to the peas, and a greater return is expected; but unless it be for the purpose of cutting them up for green fodder, as soon as the pods are formed, this practice is not to be recommended. In Flanders, peas, beans, tares, and barley are sometimes sown thick together, and form an abundant green crop, which is cut as soon as the flower is past, and given to the cows and pigs, which thrive well on this succulent food. The surface of the ground is so completely shaded, that no weeds can spring up; and as there has been no seed formed, little is taken from the soil. The land is immediately ploughed up, and sown with another crop, such as potatoes or turnips, which sometimes are off the ground in time to allow wheat to be sown the same year.

The nutritiveness of the pea as food is explained by analysis, which shows that air-dried peas generally contain about one quarter of their weight of flesh-forming constituents; one half their weight of starch, sugar, fat; and the rest fibre, water, and ash. The mineral part of the ash of the whole plant contains a very large proportion (40 per cent.) of lime, and 17 or 18 per cent. of the alkalies.

PEACE OF RYSWICK. [Treaties, Chronological Table of.]

PEACH. The peach-tree (*Amygdalus Persica*, or *Persica vulgaris*) is generally considered to be more especially a native of Persia. It was known to the Romans, and brought to Italy, where it became distinguished by the name of *Persica*; and this name it still retains under various modifications in the different countries of Europe. But the peach is not indigenous solely in Persia, for it has been found growing wild in various parts of Turkey and Asia. Pallas describes it as existing in the more southern parts of the Caucasus. From the frequency of its occurrence in a wild state, and the perfection which it attains under the most limited share of cultivation in regions situated between 30° and 40° of latitude, these parallels may be presumed to include its favourite habitat. Isothermal lines describe however a wavy tract, and the peach may even find a congenial climate to a considerable extent on both sides of the above limits; but the locality must be very peculiarly circumstanced in which it will acquire full perfection beyond the 48th parallel on the one hand; and, on the other, its deciduous nature, requiring a cool season of rest, unfits it for the continued high temperature of a tropical climate.

The peach withstands our winters unhurt, trained against a wall, if they are not unusually severe. It even succeeds in America exceedingly well as a standard, in latitudes where the winters are much more intense, but the summers hotter, than with us. This is in conformity with the well-ascertained fact, that all deciduous trees suffer less from severe frost in winter when their wood is perfectly matured by sufficiently warm summers, than when grown in climates where they cannot enjoy that degree of summer-heat which they are naturally adapted for, and which they require for the due formation of their tissues. Hence, in the north of England, young peach-trees in the open ground will be partially injured by a degree of frost which, though of equal intensity, will not injuriously affect similar plants in the neighbourhood of London. The peach also succeeds as a standard in Italy, the south of France, and other continental countries of Europe having summers equally hot; but it may be observed that, where the mean temperature of the summer months is above 70°, or that of the warmest month above 75°, as is the case at Rome, and still higher at New York, the *melting* varieties of the peach do not possess that rich succulence which they acquire against a south wall under the more moderate summer heats of the climates of London or Paris. On the contrary, however, the *firm-fleshed* or *clingstone* peaches, which are little esteemed in this country, are preferred in America and other places subject to extreme summer heat.

If the mean temperature of February amount to 40°, and that of March to 44° or 45°, the peach-tree will be in full flower against a wall with a south aspect about the last week in March; and the general crop will be ripe in the last week of August or first week of September, provided the mean temperature of April be 49°, May 55°, June 61°, July 64°, and that of August 63°. This period of *five* months required for the maturing of the fruit from the time of flowering, on the open wall, may be reduced to *four* by means of fire-heat and the protection of glass; but it cannot be advantageously diminished any further. This fact being borne in mind, it is easy for the gardener to know at what time to commence forcing his peaches in order to obtain a crop in a given month.

From the natural climate and habit of the peach-tree, it is obvious that when forced it must be flowered under a comparatively low degree of temperature. It cannot, therefore, be well forced simultaneously with the vine; for the temperature of March, which in this climate serves to bring the peach into flower, does not unfold the buds of the vine, this being only effected a month or six weeks farther in the season, by a mean temperature of 55°. The peach may be subjected at first to a temperature of 45°, but not exceeding 55° till the flowering is over, after which it may be gradually raised to 60°, and not exceeding 65°, till the substance of the stone is indurated, after which from 65° to 70° may be allowed. This is to be understood as referring to the application of fire-heat. Even in the total absence of fire-heat, sun-heat will frequently raise the temperature much higher; but in this case a large portion of air should be supplied, not however all at once after the temperature of the house is found too high, but gradually as the temperature increases. Air should be always freely admitted through the day, when the weather is at all favourable.

Light is so essential, that unless peaches be trained near the glass, the fruit will neither acquire due colour nor flavour. Vicissitudes of dryness and moisture must be avoided. The roots should be well supplied with water before the fruit begins to ripen off, because at a later period none can be applied without deteriorating the flavour.

The management of the peach-tree can only be correctly understood by those who are aware of the disposition of its buds and its mode of bearing. The leaves on the shoots of the current season are produced either singly, in pairs, or in threes from the same node. In the course of the summer, or early part of autumn, a bud is formed in the axil of every individual leaf, and these are termed single, double, or triple *eyes*, or buds, according as one or more are produced at each node. In the following season, these buds develope themselves either as flower-buds or young shoots, and previously to pruning it is necessary to distinguish the one description from the other. The flower-buds are plump and roundish; the wood-buds are more oblong and pointed, and one of these is generally situated between flower-buds in the case of triple buds occurring at the same node. It is therefore expedient, in pruning, to shorten a shoot to these triple eyes if possible, or, in their absence, to a leaf-bud, but never to a fruit-bud only, for no shoot could be prolonged from it, nor would the fruit attain perfection, owing to the want of leaves in immediate connection with its footstalk. In selecting buds for the purpose of propagation, *single* wood-buds only should be chosen.

The mode of bearing is solely on shoots of the preceding summer's growth.

The peach is propagated almost exclusively by budding; but occasionally splice-grafting is adopted. The peach stock is rarely used, but frequently the almond, especially in France. In this country, however, it is propagated almost entirely on the plum stock, which is not only much hardier, but also possesses the property of spreading its roots nearer the surface than either of the two preceding kinds, thereby affording to the peach a more congenial nourishment, in consequence of the roots being within the influence of the solar heat. Whereas the peach stock tends to strike downwards strong tap-like roots beyond the depth of the stratum warmed by the summer-heat; and although the latter trees grow vigorously for a few years, or so long as the roots have not penetrated too deep, yet they afterwards become sickly, their foliage becomes narrow, and acquires a yellowish colour, and the trees ultimately perish. The *mussel* and *white pear-plum* are the varieties of plum stocks on which the peach is budded; the latter is esteemed the best. The French prefer the St. Julien plum stock, which answers exceedingly well. In order to obtain varieties, the seed is used, and when the plant is sufficiently advanced it is grafted.

The peach succeeds in any rich fresh loamy soil; but the subsoil, like that for all fruit-trees, ought not to be retentive, and a very complete mode of drainage is absolutely necessary. It would also be desirable that the roots should not be allowed to penetrate deeper than two feet from the surface, which is to be effected by judicious root-pruning. No objections could be made against the roots following their natural tendency downwards to whatever distance they might go, if their extremities were at the same time in a medium congenial to the peach as regards temperature; but this cannot be the case in Britain, unless perhaps some chalk subsoils may form exceptions. The soil, especially if the situation is cold and damp, can hardly be too shallow when it rests on a hard subsoil; on gravel it need not exceed 14 inches in depth, but may be deeper in warm and dry situations. The best remedy for mildew is, to take up the tree carefully in autumn, renew the soil, and replant the tree, spreading the roots near the surface.

Various modes of training the peach have been adopted, with different degrees of success. That of course has proved the best which admits of the most equal distribution of sap throughout the respective branches, and likewise the production of a sufficient number of well-placed shoots for replacing those that have once borne fruit, the shoots being only useful for such purpose in the season immediately following that in which they are produced. The fan method, and a modification of it called Seymour's training, are most in conformity with the above principles. A common error in the fan method is that of disposing a few of the first produced branches so as to represent equidistant radii; the consequences of such disposition are an excessive degree of vigour in the central and most upright; but at the same time those inclining horizontally become comparatively weak, linger for a few years, and then die off. Their share of the sap is soon appropriated by the more vertical branches, some of which will assume the character of stems, and prove unsuitable for producing fruit-bearing shoots. Cutting these back is frequently the only alternative in order to obtain other shoots for the purpose of furnishing the lower part of the wall. By this misdirection of the energies of the tree, several years' growth is wasted; and when it becomes necessary to cut out such large branches, the tree receives a shock which renders it incapable of bearing such fine fruit as a more skilful management will ensure. It may be briefly affirmed that all methods of training are bad which admit upright shoots to compete with horizontal ones; for the former will grow with a vigour ten times greater, in many instances, than the latter, owing to the strong vertical tendency of the sap. Although the ascendancy gained by a vertical shoot over a horizontal one is considerable in the current season of their production, yet it bears but a trifling ratio to that which would be gained in successive seasons, were the vertical portion allowed to proceed without interference from the pruning-knife. If, however, a central vertical shoot be annually trained, and uniformly cut at the winter pruning to within a few buds from its base, no material injury would then result to the side branches, the vertical tendency against them being thus limited to a single summer-shoot. This principle is the basis of the following mode of training.

In cutting back the central shoot, two buds, well situated for producing side branches, and a third for an upright, must be left. The first production of side branches, which are intended to produce the lower radii of the fan, must be trained at some elevation in the first instance, and afterwards brought to a horizontal position; and they should not be subdivided. Those, however, obtained in the following season may be allowed to form two each, if sufficiently vigorous, at some distance from their base, and as their divergence affords room. The branches produced after those last mentioned, and indeed all the upper ones, may be subdivided into two, or even three. By this method of training the lower branches become strong, and acquire a well-established communication with the roots before the upper are in existence, so that there is little danger of their dying off, as usually happens when horizontal and vertical branches are started at the same time.

By repeating the process here detailed, all the principal branches are ultimately produced, to the number of between thirty and forty, and disposed in a fan-like form, diverging, not exactly from a common centre, but from a short axis. These branches support the shoots on which, during the second season of their existence, the fruit is borne. Buds for the origin of these shoots should be selected at the distance of every twelve or fourteen inches along the upper side of the branches, that being the side from which they are obtained with the greatest facility, owing to the upward tendency of the sap. As these shoots are being prolonged during the summer, they should be trained so that their foliage may have the fullest exposure to light; but although the foliage of one shoot ought not to overshade that of others, yet the naked branches are benefited by the shade of leaves, for old bark exposed to the direct rays of the sun is apt to be scorched.

The shoots produced and trained during the summer for successional bearing ones must be shortened considerably at the ensuing winter's pruning, and care must be taken not to cut above a node where there is only a blossom-bud or buds, but to one that is seen to have a wood-bud—that is, such as a shoot will proceed from. In the following spring, the blossom-buds are unfolded, and soon after the wood-buds begin to push the rudiments of shoots, one of which, next the base of each fruit-bearing shoot, must be preserved and encouraged with special care, in order to supply the place of those that are bearing fruit. The fruit-bearing shoots being useless for such purpose a second time, must therefore be cut away at the following winter pruning, when the young shoot, retained during the summer, is shortened like its predecessor, and trained for the purpose of bearing fruit and producing a successor, which likewise becomes subject to the same routine treatment.

The preceding directions are to be followed in order to the essential pruning, the development and maintenance of the form of the tree; but as a great number of superfluous shoots will be produced, the mode of their removal requires to be noticed. The operation is termed disbudding, and it commences as soon as the young shoots can be laid hold of, but should be completed in a gradual manner. A portion of such front-shoots as have no fruit at their bases are first removed, then part of those elsewhere situated, making exceptions of the lowest on each bearing shoot, for succession, and of the terminal one. By degrees all are removed excepting the two last mentioned and those from nodes where fruit is set and promises to attain perfection. Finally, the terminal ones and those left on account of having fruit at their bases are shortened, or stopped, to about three inches in length, or so as to have several leaves for the purpose of maintaining the flow of sap and elaborating it for the nourishment of the fruit. Should these or the terminal shoots again push, such secondary shoots must be pinched off above the second leaf from the origin.

Thinning the fruit is generally done much too sparingly. The vigour of the tree should of course be taken into consideration. As a general rule, one fruit on each bearing shoot, or two at most, are all that ought to be left. By leaving too many, the size of the fruit is diminished, so that the aggregate weight of flesh is probably but little if at all increased, whilst that of stones, to the great weakening of the tree, becomes materially so. Some remove the flower-buds to a considerable extent, a practice which is very proper. It is advisable however to preserve several on each shoot, in order that a choice may be made of one or two of those likely to take the lead.

The surface of the border should be frequently stirred; and when the weather is dry, watering will be necessary both for the border and foliage; but the use of cold spring water must be avoided. The ravages of the green fly (*Aphis Persicæ*) must be carefully guarded against. The best known remedy is to dust the tree, after syringing, with snuff, or powdered tobacco leaves. Coping-boards, made to project about a foot, are of great utility in protecting the blossoms; but after the danger of frost is over, the coping ought to be removed.

The best varieties of peaches in cultivation at the present day in this country appear to have been obtained from France. Although designated by various English names, most of the sorts have been traced to be synonymous with the French peaches. They are numerous and often changing.

(*Hort. Trans.*; *Guide to the Orchard and Kitchen Garden*; Loudon, *Encyclopædia of Gardening*; MacIntosh, *Book of the Garden*.)

PEAR, the wild pear-tree (*Pyrus communis*), from which the numerous cultivated varieties have originated, has a wide indigenous range extending over a great part of Europe and Asia, within the limits of temperate regions. It is to be met with in certain localities in the southern parts of Britain. The old varieties of pear are however getting rapidly out of cultivation, and giving place to others of recent origin, superior in quality, and much better adapted for this climate than the old kinds appear ever to have been. Few of the latter could be successfully cultivated without the aid of walls; whereas most of the new varieties produce abundance of excellent fruit on standards or dwarfs in the open ground. Even in France the old varieties are now decaying, although the climate is there most congenial to them.

The pear is chiefly propagated by grafting or budding on the wild pear stock, or on stocks raised from the seeds of cultivated pears, called free stocks; the former are however to be preferred. It is also grafted on the quince, which is most proper for dwarf trees, or for moist soil, and has also the effect of bringing the trees earlier into a bearing state. It may be also grown upon the medlar, and the white thorn (Cratægus Oxyacantha), but on these the disparity of growth between the respective stems occasions a short duration of the union. The enlargement of the pear-stem in the case of strong growing varieties is indeed generally too much for quince stocks. There are several varieties of the quince, and the sort that has the broadest leaves and which has the nearest correspondence in regard to horizontal growth with that of the pear should be preferred for stocks.

The pear-tree will thrive in any rich loamy soil; but it is only where the subsoil is naturally congenial, or rendered so artificially, that it will continue to produce good crops of well flavoured fruit. A clay subsoil is bad, and so is in fact any other that will hold water. Good drainage is absolutely necessary, and shallow planting cannot be too much recommended. The monks in former times were aware of the advantages arising from having the roots near the surface; for stones and slates have been found below old fruit-trees, which had been planted at monasteries once in their possession.

Manure is not so liable to prove injurious to the pear and apple as it is to stone-fruits. On the contrary, unless the trees be growing too strong, manure, judiciously applied, will always prove beneficial.

Pears are deemed worthy of the expense of walls, but this is often an unnecessary expenditure for want of a properly formed border, and thorough draining, where the subsoil renders such necessary. Brick-rubbish is a good bottoming; or a bed of concrete, two or three inches thick, laid sloping from the wall towards a drain in front, is unquestionably one of the best modes that could be practised; and it is the only effectual one to prevent the roots from penetrating beyond a limited depth; for they will often find their way through a stratum of stones or brick-rubbish. The depth of soil need not exceed 2½ feet. The best season for transplanting is in the beginning of winter, or as soon as the leaves have fallen in autumn.

Standard trees may be planted from 20 to 30 feet apart, or where vegetables are intended to be cultivated, the distances may be 40 feet between the rows and 20 feet in the rows. Dwarf trees, or quince stocks, will not require more than 15 feet distance. Wall-trees should be at least 20 feet apart, and for some varieties 30 feet will not be too much.

The modes of training the pear-tree are various. Against walls, the three principal methods are the fan-shape, its reverse the pendulous, and intermediately the horizontal, which is that most generally adopted. In the fan method the central part of the tree, from the upright position of the branches, or their near approach to such, is apt to become too strong. On the contrary, the pendulous training induces debility when the trees begin to bear heavy crops. By annually cutting back a central shoot to about a foot, and training branches horizontally, right and left, the vigour of the tree is equally distributed. It often happens that in this mode the branches only produce fruit towards their extremities. When this is the case, a shoot should be encouraged near the origin of the horizontal branch, and trained in the interval, and at some distance, say three feet; farther along the branches another may be laid in a similar manner, and so on, care being taken that each is stopped when its elongation reaches the place where another has its origin. These shoots will generally become as fruitful, after two or three years, as the portion of wood of the same age near the extremities of the branches themselves.

Training against espaliers was formerly more practised than at present. The difficulty of getting the old varieties to bear apart from a wall, together with the expense of erecting the espalier, and the liability of its materials to decay, have no doubt tended to bring this mode into disuse. It is however worthy of remark, that a greater extent of foliage can be exposed to direct light by espalier training than by any other on an equal extent of ground. New varieties will do away with the objection of unproductiveness; and although the contact of metallic substances is not congenial to vegetable growth, yet the principal supports of the espalier might be constructed of cast-iron, which would prove an ultimate saving; the small intermediate wood-work that would be requisite could be easily replaced.

In the cultivation of pears as standards, the head is allowed to take nearly its natural course, being only subjected to such regulations, by pruning, as are necessary to preserve the equality of the principal branches with regard both to strength and distance; and likewise to render the whole sufficiently thin, in order that the sun's rays may be freely admitted.

In some situations, many kinds of pears remain long unfruitful; the best means of rendering them otherwise is of course a most important desideratum. So long as circumstances are very favourable for the growth of wood, blossom-buds are not likely to be produced; the production of the latter results from a more inspissated state of the juices; and will not take place whilst a copious flow of sap is continued. This may be interrupted by ligature, ringing, grafting, or other analogous means. But these means frequently afford only a temporary remedy, and a repetition of the process is at the expense of the energies of the tree, so that it is rendered too weak for future bearing. There is still a more important object which the above means are not calculated to affect. If the roots are in a cold subsoil or out of the reach of solar influence, the fruit will only acquire an inferior degree of flavour. If however the tree be carefully removed (for doing which autumn is the best season), the soil well dug, or even renewed, and the tree deprived of such roots as cannot be brought to a horizontal position, namely, that in which all the others should be placed when replanted, and if this be done as shallow as possible, a satisfactory check will be occasioned, fruitfulness induced, and flavour communicated.

The management of dwarf standards is similar to that required for tall standards, excepting that the head is formed at the height of one or two feet from the ground, instead of six, the usual height allowed for the stems of standard trees in orchards, or where under-cropping is carried on, as in market-gardens, where the dwarf-headed trees would obstruct the growth of vegetables for a considerable distance from their stem. Dwarfs however have some important advantages; a large head is sooner formed, and the fruit is not so liable to be blown down.

The French modes of training *en Quenouille* or *en Pyramide* cannot be strictly adopted in this country with advantage, owing to the richness of the soil and moisture of the climate, circumstances which are favourable to the production of shoots rather than fruit-buds, and this tendency is farther encouraged by shortening the shoots to the extent which the French recommend. In both these modes tiers of branches proceed from a central stem; in the pyramidal form the branches are horizontal, each tier being successively shorter than the one below. In the Quenouille the branches are curved downwards, and this mode might be successfully practised in this country, by leaving the shoots at full length, care being taken that all upright shoots are shortened in summer.

The pruning of standard pear-trees is usually confined to the winter regulation of the branches by thinning, and shortening where the subdivision of branches is desirable or where they are too weak. Wall and espalier trees require both a summer and winter pruning. In summer a number of shoots will be produced beyond that which will be required for training. If these are allowed to grow without interruption during a considerable part of the season, and then at once cleared away, the tree is apt to receive a shock from which it does not soon recover. If the shoots are shortened too much or too early, the buds, which would otherwise have proved blossom buds in the following spring, will immediately become excited (other channels for the flow of sap being cut off), and burst into shoots. [MORPHOLOGY.]

In order to avoid this, which is a case of frequent occurrence, a portion of these superfluous shoots should be first stopped at an early period, and afterwards another portion: by the middle of June part of them may be cut back to within two or three inches of their base; and thus by degrees the whole will be ultimately reduced, without any great or sudden derangement of the general flow of the sap. The winter pruning is attended with less vital danger to the tree. It consists chiefly in shortening spurs to the lowest fruit-buds and judiciously thinning them.

If borders are well made, there will be less occasion for raising the trees after they have been once planted. Still, after four or five years, it will, under all circumstances, prove advantageous to remove the trees from the wall, trench the border, and replant, spreading the roots near the surface in a horizontal direction, or inclining slightly downwards. Cutting the roots, without entirely removing the tree, is attended with the disadvantages arising from the partial loosening of the soil, and the difficulty of reaching the perpendicular portions of the root.

PEAR-GAGE. The principle of Smeaton's pear-gage, for measuring the exhaustion of a receiver, by means of the AIR PUMP, differs from that of the other gages, in that the measurement does not take place until after the air has been re-admitted into the receiver. Suppose a wire working through a collar in the top of the receiver and supporting a tube open only at the lower end. Under the tube is a cup of mercury, standing on the floor of the receiver, so that by lowering the wire the open end of the tube may be immersed in the mercury. The exhaustion being made before lowering the wire, the air in the tube will be rarefied equally with that in the rest of the receiver. If the wire be then lowered, and the air re-admitted into the receiver, the mercury will rise in the tube until the elastic force of the recompressed air in the tube, together with the column of mercury, counterbalances the pressure of the external air. A gage attached to the tube shows, by the height of the mercury, what was the original rarefaction.

Now it is plain that while the ordinary gages show the actual amount of elastic force left in the receiver, the pear-gage submits the air, or whatever else there may be, to a process of compression before the measurement is made. If there be nothing but air, all the gages agree; but if, as generally is the case, there be also vapour, the pear-gage shows a much higher degree of apparent exhaustion, than the ordinary gage.

PEARLASH. [POTASSIUM.]

PEARL FISHERY. The fisheries which are carried on to supply the market of the world with pearls are numerous, and some of them are of very ancient date. The fishery at Catifa in Arabia, which produced the pearl bought by Tavernier for 110,000*l.*, was celebrated in Pliny's time. In the Old World, the west coast of Ceylon, that of Coromandel, and the Persian Gulf, are among the more prominent stations. The Algerine coast and the Sooloo Islands also furnish a certain share. In the New World, the neighbourhood of St. Margarita, or Pearl Island, and other localities on the coast of Colombia, furnish a great many, and the Bay of Panama also contributes considerably; but the pearls from the Western world, though many of them are large, cannot be compared with those of the East in shape, colour, and general beauty.

The Bahrein Islands (Persian Gulf) give a most abundant harvest of these beautiful molluscous secretions; perhaps the most abundant in the world. Sixty thousand tomauns of Bassorah, about 90,000*l.* sterling of our money, and often more, are derived from the fishery in about two months, the time during which it lasts, the commencement being in June. There is no monopoly; any one may engage in the adventure upon payment of a tax on the produce to the government. The Persians principally are engaged in it, and the divers are of that nation.

The Western pearl fisheries, especially those on the coast of Colombia, must have been very valuable once. Seville alone is said to have imported upwards of 697 lbs. in the year 1587. The second Philip's celebrated pearl, which weighed 250 carats, and was valued at 150,000 dollars, came from Margarita. These prizes were not forgotten in 1825, when joint-stock companies raged. One company undertook the prosecution of the Colombia fishery, and another embarked in that of Panama and the Pacific, both with about the same success; for in 1826 they were abandoned. Some fine specimens of the shells of Mollusca were sent home by one of them. The Algerine ground was also, we believe, undertaken by an English company in 1826.

The pearls which are the objects of these fisheries are found in the shells of *Meleagrinæ*, or pearl-oysters, as they are called, and principally in those of the species named *Avicula* or *Meleagrina margaritifera*. The best ground is considered to range at depths varying from 6 to 8 fathoms; and the divers, who usually are unhealthy and short-lived, are said to be able to remain generally from a minute to a minute and a half under water. Two minutes, four, and even six, have been mentioned; but constructed as the human respiratory and circulating system is, we should think the last-mentioned periods must be very rare. A submersion of a minute and a half is calculated to do mischief enough in ordinary cases.

Ceylon affords a good example of the commercial system under which the pearl-fishery is carried on. The bay of Condatchy is the most central rendezvous for the boats employed in the fishery. The banks, where it is carried on, extend several miles along the coast from Manaar southward off Arippo, Condatchy, and Pomparipoo. The principal bank is opposite to Condatchy, and lies out at sea about twenty miles. After the survey of the state of the beds and the consequent report to government, the particular banks to be fished are put up for sale to the highest bidder, and are usually purchased by a native merchant. The government however sometimes judges it more advantageous to fish the banks on its own account, and to dispose of the pearls to the merchants. The banks are divided into three or four different portions, which are fished annually in succession. These portions are completely distinct, and are set up separately to sale, each in the year in which it is to be fished. A sufficient interval is thus given to the oysters to attain their proper growth; and as the portion first used has generally recovered its maturity by the time the last portion has been fished, the fishery becomes almost regularly annual, and may thus be considered as yielding a yearly revenue. The oysters are supposed to attain their complete state of maturity in seven years. The fishing season commences in February, and ends about the beginning of April. The period allowed to the merchant to fish the banks is six weeks or two months at the utmost; but there are several interruptions which prevent the fishing days from exceeding more than about thirty. If it happen to be a very bad season, and many stormy days intervene during the period allotted, the purchaser of the fishery is often allowed a few days more. Previous to the commencement of the fishery, all the boats rendezvous at Condatchy, and it is here that they are numbered and contracted for. They regularly sail out and return together. They reach the banks before day-break, and at sun-rise commence fishing. In this they continue busily occupied till the sea-breeze, which arises about noon, warns them to return to the bay. When the boats come to land, their cargoes are immediately taken out, as it is necessary to have them completely unloaded before night. Each boat carries twenty men, with a tindal, or chief boatman, who acts as pilot. Ten of the men row and assist the divers in reascending. The other ten are divers; they go down into the sea by five at a time; when the first five come up, the other five go down; and by this method of alternately diving, they give each other time to recruit themselves for a fresh plunge. In order to accelerate the descent of the divers, large stones are employed. Some of the divers use a stone shaped like a half-moon, which they fasten round the belly when they mean to descend, and thus keep their feet free. They fearlessly descend to the bottom in from four to ten fathoms water in search of the oysters. The diver, when he is about to plunge, seizes the rope to which one of the stones is attached, with the toes of his right foot; while he takes hold of a bag of net-work with those of his left. He seizes another rope with his right hand, and holding his nostrils shut with his left, plunges into the water, and by the assistance of the stone speedily reaches the bottom. He then hangs the net round his neck, and with much dexterity and all possible despatch collects as many oysters as he can while he is able to remain under water. He then resumes his former position, makes a signal to those above by pulling the rope in his right hand, and is immediately by this means drawn up and brought into the boat. These men will often make from forty to fifty plunges in one day, and at each plunge bring up about a hundred oysters. Some rub their bodies over with oil, and stuff their ears and noses to prevent the water from entering; while others use no precautions whatever. The chief horror and danger awaiting the diver are concentrated in the ground-shark. This animal is a common and fearful inhabitant of all the seas in these latitudes: and its terrors are so continually before the eyes of the divers, that they seek a vague safety in supernatural means.

The divers are paid differently, according to their private agreement with the boat-owners, either in money or with a proportion of the oysters caught, which they take the chance of opening on their own account: the latter is the method most commonly adopted. The agreements with the people who hire out the boats are conducted much in the same manner. They contract either to receive a certain sum for the use of their boats, or pay the chief farmer of the banks a certain sum for permission to fish on their own account. Some of those who pursue the latter plan are very successful and become rich, while others are great losers by the speculation. The spirit of gambling is more openly exhibited, for oyster lotteries are carried on to a great extent, and they consist of purchasing a quantity of the oysters unopened, and running the chance of either finding or not finding pearls in them. As soon as the oysters are taken out of the boats, they are carried by the different people to whom they belong and placed in holes or pits dug in the ground to the depth of about 2 feet, or in small square places cleared and fenced round for the purpose, each person having his own separate division. Mats are spread below them to prevent the oysters from touching the earth, and here they are left to die and rot. As soon as they have passed through a state of putrefaction and have become dry, they are easily opened without any danger of injuring the pearls. On the shell being opened, the oyster is minutely examined for the pearls; it is usual even to boil the oyster, as the pearl, though commonly found in the shell, is not unfrequently contained in the body of the fish itself.

Captain Percival, in his account of Ceylon, states that in preparing the pearls, particularly in drilling and stringing them, the natives are wonderfully expert. A machine made of wood, and of a shape resembling an obtuse inverted cone, about six inches in length and four in breadth, is supported upon three feet, each twelve inches long. In the upper flat surface of this machine holes or pits are formed to receive the larger pearls, the smaller ones being beat in with a little wooden hammer. The drilling instruments are spindles of various sizes, according to that of the pearls; they are turned round in a wooden head by means of a bow handle, to which they are attached. The pearls being placed in the holes, and the point of the spindle adjusted to them, the workman presses on the wooden head of the machine with his left hand, while his right is employed in turning round the bow handle. During the process of drilling, he occasionally moistens the pearl by dipping the little finger of his right hand in a cocoa-nut filled with water, which is placed by him for that purpose; this he does with a dexterity and quickness which scarcely impede the operation, and can only be acquired by much practice. The Cingalese have also a variety of other instruments both for cutting and drilling the pearls. To clean, round, and polish them to the state in which we see them, a powder, made of the pearls themselves, is employed. These different operations in preparing the pearls occupy a great number of the natives in various parts of the island. In the black town or pettah of Columbo in particular, many of them may every day be seen at this work.

The Chinese adopt a singular mode of procuring pearls by artificial means, that of compelling or inducing the fish to make them. They force open the shell of a large river mussel, and put in a small bit of wood or metal. The fish becomes irritated, and covers the intruding substance with a pearly deposit. Very often small clay figures are thus introduced, representing Buddha in the sitting posture in which that image is most frequently pourtrayed. It has been stated that no less than 5000 families are engaged in this singular branch of industry near Ningpo. Some of these pearl-covered figures of Buddha are to be seen in the South Kensington Museum.

The beautiful substance called (somewhat expressively) *mother of pearl*, is the hard, lustrous, brilliant internal layer of shells, especially oyster shells, and more particularly the pearl oyster. In English oysters this substance is too thin to be workable for manufacturing purposes; but the oysters of the eastern seas yield it of considerable thickness. The brilliant hues which distinguish mother of pearl do not depend upon the nature of the substance, but on an exquisitely fine series of furrows upon the surface, which shed a brilliant reflection of colours according to the angle at which the light falls on them. Much care is required in working this delicate substance; but it may be cut by saws, files, and drills, with the corrosive aid of sulphuric or muriatic acid. It is polished by colcothar of vitriol. In all those ornamental manufactures where *pearl* is said to be used for flat surfaces, such as inlaying, mosaics, buttons, knife-handles, &c., it is not real pearl, but mother of pearl, that is employed; and the quantity now consumed in England, especially at the manufacturing establishments of Birmingham and Sheffield, is very large. An instance has been recorded of a ship arriving at London from Panama with more than *two million* pearl shells.

PEARL WHITE. [Bismuth, *Nitrate of.*]

PEAT: *Economical Uses.* Peat is a substance of vegetable origin, found wherever the soil has been long soaked with water which has no outlet and does not completely evaporate by the heat of the sun. When dried peat is examined, it is found to consist of roots and fibres in every stage of decomposition, from the natural wood to the completely black vegetable mould. From the nature of its formation under the surface of water, it acquires a portion of tannin, which has the property of preserving animal and vegetable matter from decomposition. Hence large branches and trunks of trees are found imbedded in peat, which have no mark of decomposition, except what may have taken place before the wood was completely immersed in the peat. Peat contains all the elements of the richest manure, and may by an easy process be converted into humus: for this purpose the agency of alkalies is the most effectual. If the tannin be decomposed, decomposition of the vegetable fibre will go on, and soluble humus will be formed. When peat is newly dug up, if caustic lime be added to it before it is dry, the moisture of the peat slakes the lime, which acts on the gallic acid in the peat and neutralises it. If this mixture be then excited to fermentation by the addition of animal matter, such as urine or dung, oxygen is absorbed and carbonic acid evolved; and the residue is converted into an excellent manure, containing much soluble humus. The same may be effected more slowly by mixing peat with clay or marl, and allowing the mixture to remain exposed to the atmosphere for a considerable time, frequently turning it. But nothing accelerates this process like the addition of putrescent animal matter, which acts as a ferment and greatly hastens the decomposition. The soils for which peat forms the best manure are the chalky and clayey. Sand has too little tenacity; it lets the gases produced by the decomposition escape, instead of attracting them, as clay and chalk do, and preventing their escape.

The burning of peat destroys the vegetable matter and leaves the earths and salts behind. They are accordingly very strong stimulants to vegetation, especially that of clovers and herbaceous plants, of which the leaves and stems are the most valuable parts. If the soil is well furnished with vegetable matter, and capable of bringing an abundance of seed to perfection, it may be very useful to apply stimulating manures, such as peat ashes, to increase the verdure; but on poor soils destitute of humus, the increase of the stems and leaves does not ensure a proportionate increase of seed. Hence it is often remarked that soot, potash, saltpetre, and similar substances produce a deceitful growth, giving a rank green leaf, which is not succeeded by a heavy ear; but, on the contrary, the produce in seed is rather diminished than increased by the use of the manure. Whenever a stimulating manure is used, the soil should be naturally rich, or enriching manure should be applied at the same time.

Where a great extent of peat-moss renders the improvement of it desirable, there are various ways in which it may be reclaimed. In some places the peat has been removed, and the loam which lay below it was found of a very fertile nature. This could only be done on the banks of rivers, into which the peat was floated by means of small canals dug through it, and communicating with the river. In all other cases the mode adopted has been that of draining and consolidating. In draining a peat-moss the water must not be let off too rapidly, for in that case the surface may become so loose and dry, that no vegetation can take place in it. If the water is drained off so as to leave two feet of peat dry above its level, this is all that is required for a beginning. The best improvement, and the most rapid, is produced by bringing sand or gravel in sufficient quantity to cover the surface with two or three inches of it. This will make a beginning of a soil, in which potatoes may be planted. At first the surface will not bear the wheels of a cart nor the tread of a horse; but in a short time a solid crust will be formed, which will increase in strength and thickness as cultivation advances. There are many fine pastures in Scotland which once were brown peat-mosses, on which it would have been dangerous for a man to walk, but which now bear heavy oxen, and seem as solid as any pasture on a clay subsoil. Manuring and liming are the most effective operations in bringing about this great improvement. Potatoes and oats are usually the first crop on reclaimed peat-mosses. It is long before they become capable of bearing wheat; nor is this crop to be recommended at any time, unless there be a good depth of soil formed over the peat. Laying down to grass as soon as a certain degree of improvement has been made, and depasturing with sheep at first and cattle afterwards, tend more than any other means to consolidate the surface and deepen the mould, which gradually increases by the decomposition of the tannin in the peat.

Great attention has been paid within the last few years to the question how far peat can be practically applied in the arts, thereby rendering a double service—clearing bog-land for agricultural purposes, and making good use of the substance taken from it. As Ireland contains 3,000,000 acres of bog, the inquiry really becomes an important one. Several years ago, a patent was obtained by Mr. Williams, managing director of the Dublin Steam Navigation Company, for compressing peat into a dense mass, so as to resemble coal. The process is as follows:—Immediately after being dug, the peat is triturated under revolving edge-wheels faced with iron plates perforated all over the surface, and is forced by the pressure through these apertures, till it becomes a species of pap, which is freed from the greater part of its moisture by a hydraulic press. It is then dried, and converted into coke in the same manner as is done with pit coal. The factitious coal of Mr. Williams is made by incorporating pitch or rosin melted in a cauldron with as much of the peat-charcoal ground to powder as will form a tough doughy mass, which is then moulded into bricks.

The use of peat for fuel is too well known to require notice; but it may be interesting to know how peat fuel is made in Holland, where it cannot be dug out of the solid moss but is brought up in the form of mud from a considerable depth under water. It is raised by means of small strong nets, fixed by an iron ring to a long pole, in the manner in which canals are cleared of mud. This liquid peat is brought in boats to a place prepared for its manufacture, which has been levelled as a brick-yard usually is. The soft mud is spread over this to the depth of six inches, and the water is allowed to drain off slowly. When the peat begins to dry, men fix boards to their feet and walk over it, so as to compress it; and as soon as it will bear cutting, it is cut with a spade made on purpose into oblong pieces of the usual size of peat, which is about eight or nine inches long and five wide; the treading and drying have reduced the thickness to about four or five inches. When completely solid, these peats are set on edge, and afterwards stacked loosely, so that the air may pass through them. In some places they have sheds, for the purpose of protecting them from rain. They soon become very hard, and burn more like wood or coal than the peat which is cut immediately from a solid moss. They give a very great heat, and form a coal which, when it is shut up in a close vessel to stop the combustion, and allowed to cool, has a considerable resemblance to charcoal.

Dutch peat is used as fuel for all the purposes of manufactures, except for the forging of iron, for which coals are imported from England and the Netherlands. The peat-fens in Holland, however, begin to be exhausted, and the fuel is so dear, that it is found more economical to import coals from England, which are used chiefly in cast-iron stoves.

In Ireland, some years ago, the Irish Amelioration Society encouraged the conversion of peat into charcoal. The charcoal obtained from this source is found to be valuable not only for smelting-furnaces, but also as a deodoriser. Around each charcoal factory, in some parts of Ireland, a rim of cottage gardens was gradually formed; and the land, relieved from the load of otherwise unprofitable peat, produced useful crops. Whether, however, from the commercial value of the product having been overstated, or for some other cause, the making of charcoal from peat still remains only a small branch of industry in Ireland. A British and Irish Peat Company was afterwards formed, suggested with reference to Dartmoor peat rather than to that of Ireland; but if available for one, it would also be for the other. The company professed to be able to obtain naphtha, paraffin, fixed oil, volatile oil, acetate of lime, and sulphate of ammonia, from peat, at profitable prices; and very sanguine accounts were published as to the rate of profit obtainable. When the Earl of Clarendon was Lord Lieutenant of Ireland, he commissioned Sir Robert Kane to inquire into and report upon the various proposed plans for economically applying the millions of acres of peat in Ireland. One difficulty is, that all attempts to expel the water from wet peat by mechanical means alone have been found defective; and another is, that the profitableness of applying heat to evaporate the moisture is doubtful. In the peat taken from the Bog of Allen, it is found that 100 tons of the wet substance produce only 16 tons of dry peat. Mr. Reece, whose patent led to the formation of the Irish Peat Company, found that by the destructive distillation of 1000 parts of peat, he obtained about eleven of sulphate of ammonia, seven of acetate of lime, two of wood naphtha, one of paraffin, seven of, fixed oil, and three of volatile oil. When Sir Robert Kane tested this statement he found it to be pretty nearly correct; but when he proceeded to inquire into the profitableness of the process as a manufacture of the above-named substances, the conflicting evidence quite baffled him. From the reports of Kane and other authorities, the area of all the bogs in Ireland, multiplied by the average thickness, would it appears yield the enormous quantity of 4,000,000,000 tons of peat even when quite dry; and some enthusiasts have given to this a money value of more than 1,000,000,000*l.* for fuel. A village has been lighted with peat gas in Westmeath. It remains true, nevertheless, that although a mass of peat is a vast storehouse of chemical material, manufacturing operations relating thereto have not yet become important.

PECK, a measure of two gallons, or the fourth part of a bushel. [BUSHEL.] It is used as a measure of dry goods only.

PECTASE. [PECTIC ACID.]

PECTIC ACID. PECTIN. The jelly of certain fruits, as the currant, gooseberry, &c., is distinguished from gelatin, or animal jelly, in containing no nitrogen. Pectic acid was first obtained by Braconnot, so named by him from the Greek *pectis* (πηκτίς); and whenever pectin is treated with an alkali, pectic acid is formed. As these substances are intimately connected, they may be considered together.

Pectin may be obtained from many fruits by carefully expressing their juice, and evaporating it at a temperature not above 212°. It may also be procured by adding alcohol to recently expressed currant or gooseberry juice; in a few hours a gelatinous substance separates, which is to be washed with weak alcohol and then dried; in this state it resembles isinglass in appearance, and when immersed in cold water it swells like starch.

Another method has been given for preparing pectin, which is that of mixing the clear expressed juice of currants with that of sour cherries, when pectin falls down; the liquid being poured off, the pectin is to be washed with cold water as long as it comes away coloured.

Hot water has less action upon dry pectin than cold water has: in dilute and boiling alcohol it dissolves slightly; the solution however is not very adhesive. Pectin has no acid properties, nor does it render iodine blue like starch. When pectin is treated with nitric acid, it yields oxalic acid and mucic acid, accompanied with a trace of a bitter yellow matter: hydrochloric acid is rendered of a fine red colour by it when they are heated together, and red flakes separate, which are not soluble in ammonia. Pectin has also been found in the bark of most trees.

Pectic acid is obtained whenever carbonate of potash is added to pectin, but carbonate of soda does not produce this effect, nor does ammonia. Lime-water, however, partially converts pectin into pectic acid.

Pectic acid is perhaps most conveniently obtained from the carrot; for this purpose the rasped root is to be washed with water, and pressed, till it ceases to dissolve anything; then 100 parts of the pressed carrot are to be boiled in water with five parts of bicarbonate of potash; the root is to be again pressed, and the clear solution, which is pectate of potash, is to be decomposed by the addition of a solution of chloride of calcium, which yields by double decomposition an insoluble pectate of lime; this is to be treated with dilute hydrochloric acid, which separates the pectic acid.

Pectic acid has the following properties: it is a colourless jelly, slightly acid, and reddens litmus paper very distinctly. When distilled it yields a product containing much empyreumatic oil, but no trace whatever of ammonia.

It is very little soluble in water, whether hot or cold, and the filtered solution acts less powerfully on litmus than the gelatinous acid. Although it contains so little of the acid, yet the solution becomes gelatinous when alcohol or sugar is added to it; lime or baryta water also occasions precipitation in it.

When gelatinous pectic acid is gently heated with an excess of caustic potash or soda in a platinum crucible, a brown-coloured solution is soon obtained; and when thus evaporated to dryness, the pectic acid is found almost entirely converted into oxalic acid.

The neutral pectates of potash, soda, and ammonia, when dissolved in water, are separated in a gelatinous state from solution by alcohol, sugar, and saline solutions, &c.

Pectic acid is decomposed by sulphuric acid when they are heated together, and nitric acid converts it into mucic and oxalic acid, &c. Most of the stronger or mineral acids also decompose the saline compounds of pectic acid; but this is not the case with the greater number of the vegetable acids.

The substance originally contained in the currants, &c., and from which pectin is supposed to be derived by the influence of acids, has been named *pectose*. This matter is also accompanied by a kind of ferment, called *pectase*. *Parapectin* is produced by boiling a solution of pectin for some hours. *Metapectin* is obtained by the transformation of parapectin in contact with boiling dilute acids. When pectase is added to a solution of pectic acid, a gelatinous body termed *pectosic acid* is formed. *Parapectic acid*, *metapectic acid*, and *pyropectic acid* are also unimportant derivatives of pectin.

Little is known as to the exact composition of these substances. The following formulæ have been proposed by different investigators, but they are all doubtful:—

Pectin . . . . $\begin{cases} C_{12}H_8O_{10} \\ C_{28}H_{21}O_{24} \\ C_{64}H_{48}O_{56} \end{cases}$

Metapectic acid . . . . . . $C_8H_5O_7+2HO$

Pyropectic acid . . . . . $C_{14}H_5O_9$

PECTIN. [PECTIC ACID.]

PECTOSE. [PECTIC ACID.]

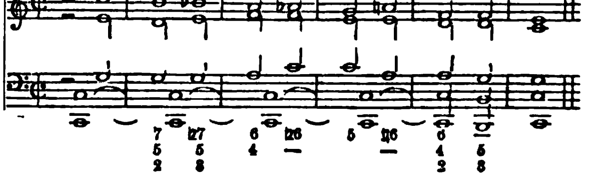
PECTOSIC ACID. [PECTIC ACID.]

PECULIARS, COURT OF, one of the ecclesiastical courts: which, until the abolition of peculiars, took cognisance of all matters arising therein. (Blackst. 'Comm.,' Mr. Kerr's ed., v. iii.)

PEDAL. In musical instruments pedals are of two kinds:—1, those keys which are acted on by the feet of the performer; 2, the levers acting on the swell of the organ, and on the stops; and also those of the pianoforte and harp, the uses of which are too well known to require explanation.

The pedals, or foot-keys, of the organ were invented in the 15th century, by a German named Bernhard; but it was long before they had travelled beyond the confines of the country to which they owed their birth; and strange to say, England was the last to adopt them, though the first to introduce the organ generally into the church. But by slow degrees their utility and importance were discovered and acknowledged, and now no organ, except of small dimensions, is built without these most desirable auxiliaries, and no organist is esteemed who is not tolerably well skilled in the use of them. [ORGAN.]

PEDAL-BASE (or *Pedale*), in music, is a base which remains stationary on one note, while the other parts continue moving and forming various chords, all of which, however, must be related to the holding note, according to the laws of harmony. Example:—



PEDESTAL. [Column.]

PEDIGREE. A pedigree is a tabular view of the members of any particular family, with the relations in which they stand to each other; together, usually, with some slight notice of the principal events of the life of each, as the time and place of birth, marriage, death, and burial, the residence, the profession, or rank of the principal person named in it, and public offices held by him. Sometimes these are accompanied by reference to evidence of the facts stated, as to inquisitions, parish-registers, monumental inscriptions, marriage-settlements, and deeds of all kinds. But when there is much of this kind of information and evidence introduced, the writing is rather called a genealogy, or genealogical history, than a pedigree; and many pedigrees, especially those of early date, are wholly deficient of reference to evidence for proof of the things stated in them, and contain rarely dates or anything more than the mere names of the parties who occur in them. They appear to be the summaries, or things established by certain evidences which may or may not now accompany them, in respect of descents and relationships.

Some fanciful explanations have been given of the word. But perhaps the true etymology may be that which refers it to the Latin *pedes graduum*, the word *pes*, or *pedes*, being much used in the law Latin of the middle ages to denote *summaries*, or the ultimate result in any transaction, as in *pedes finium* and *pedes compoti*. So that a pedigree is, as it were, a *total* of information or evidence respecting descents and kindredships.

The Scripture genealogies, as they are called, are so many pedigrees, but with this difference from the proper idea of a pedigree, that they are not tabular, but narrative.

Tabular genealogies, or pedigrees properly so called, are not of very frequent occurrence in the writings of the middle ages. But they are sometimes found in public records, and in the evidences of private families, or entered in the chartularies of the monastic foundations. They are generally short, containing for the most part only such matter as was wanted for the exhibition of some particular claim of right. But at about the beginning of the 16th century, when the College of Heralds began to pay more attention to the genealogy of the English families in reference to their claims to dignities and to the distinction which the right to armorial insignia gives, many pedigrees were compiled, and in the course of that century the heralds obtained copies of all such accounts of the English families of any distinction as could be supplied to them, and made such accounts matter of public record by entering them in the books which contain the record of their official proceedings. To obtain information of this kind, it was the practice of the heralds of that century, and it continued to be their practice till about the year 1680, to visit the various counties of England from time to time in turn, and to collect from the mouths of the principal persons of each county what they knew of the changes which had taken place in the family since the time of the preceding visitation, or what account could be given of themselves by families who had recently stepped into the rank of gentry, or who had become recently settled in the county. The pedigrees thus collected are in the visitation books at the College of Arms, and form a vast body of this species of information highly important to those who are studying critically the biography of the distinguished persons of the English nation.

Besides this grand collection of pedigrees, there are many similar collections made by private persons, or by the heralds themselves in their private capacity. Many such collections are in the library of the Heralds' College; others are in the British Museum; others in the hands of private persons. Copies of the visitation books are also often to be found. The largest collection of copies is in the British Museum, though copies of some of the best visitation books are not in any of the collections in that depository. There are many copies in the libraries of Queen's College, Oxford, and Caius College, Cambridge.

Since the visitations were discontinued, there has been no official and regular collection of pedigrees. But there has been a continual addition made to the pedigrees which are on record in the visitation books by the entry in the books of the Heralds' College of their pedigree by particular families. In some cases, as of peers, this is compulsory. When arms are granted or dignities conferred, it has been usual for families to record in the college what they know of their descents and alliances. But the books are open to any private family, who may, at a moderate expense, enter a pedigree showing the existing state of the family, and whatever is within the recollection of the older members of it, or can be proved by sufficient evidence. The entries thus officially made are matter of record, and contain information which is often very interesting to the posterity of the persons who occur in them, and may be of importance in protecting rights which belong to them.

The authors of the books of topography have done something to supply the loss of information of this kind which has been sustained by the disuse of visitations, such works usually containing notices of the families who have possessed the more important interests in the district to which the work relates.

PEDIMENT. [Grecian Architecture.]

PEDLAR. This word is said by Dr. Johnson to be a contraction from *petty dealer*, formed into a new term by long and familiar use; and a pedlar is defined by him to be "one who travels the country with small commodities." The same writer defines a *hawker* to be "one who sells his wares by proclaiming them in the street." In legal understanding however a hawker is an itinerant trader, who goes about from place to place, carrying with him and selling goods; and a pedlar is only a hawker in small wares. In the various acts of parliament which impose duties upon them and regulate their dealings, they are always named in conjunction as hawkers and pedlars; and no distinction is made between them.

It has been for more than a century the policy of English law to consider the conduct of trade by means of fixed establishments as more beneficial to the public than that of itinerant dealers; and it cannot be denied that the local trader being better known and more dependent upon his character than one who continually travels from place to place, there is a greater security for the respectability of his dealings. In conformity with this policy, statutes have been passed from time to time, obliging hawkers and pedlars to take out licences and to submit to specific regulations and restrictions, which are supposed to protect the resident trader as well as the public from unfair dealing. These reasons however have been given *ex post facto* to justify the laws; for the statutes which originally required licences for hawkers and imposed these duties appear to have merely contemplated a means of increasing the revenue. (8 & 9 Wm. III., c. 25; and 9 & 10 Wm. III., c. 27.)

The provisions by which the licences to hawkers and pedlars are now regulated are contained in the statute 50 Geo. III., c. 41; and the Amendment Act 52 Geo. III., c. 108. The duty of granting licences to hawkers and pedlars and enforcing the law against such persons is now entrusted to the commissioners of stamps, under the 1 & 2 Wm. IV., c. 22; the particular conditions and regulations under which such licences are to be granted being contained in the above-mentioned statute, 50 Geo. III., c. 41.

Before a licence is granted to a person desirous of trading and travelling as a hawker or pedlar, the applicant must produce to the commissioners of stamps a certificate, signed by the officiating clergyman and two householders within the parish in which he resides, attesting that he is of good character and a fit person to be licensed. Upon this certificate being given, the commissioners grant the licence, which is only in force for one year, and the party who receives it is subject to a duty of 4*l.* per annum, if he travels on foot or with horses alone, and an additional duty of 4*l.* per annum if he travels with a "horse, ass, mule, or other beast bearing or drawing burthen;" and these duties are to be paid at the time of receiving the licence. All persons who act as hawkers or pedlars without such a licence are liable to a penalty of 50*l.* Among other regulations, the hawker or pedlar is required by the act to "cause to be written in large legible Roman capitals, upon the most conspicuous part of every pack, box, bag, trunk, case, cart, or waggon, or other vehicle in which he carries his goods, and of every room and shop in which he trades, and likewise upon every handbill or advertisement given out by him, the words 'Licensed Hawker,' together with the number, name, or other mark of his licence;" and in case of his omission so to do, he is liable to a penalty of 10*l.*; and every unlicensed person who places these words upon his goods is liable to a penalty to the like amount. A hawker and pedlar travelling without a licence, or travelling and trading contrary to or otherwise than is allowed by the terms of his licence, or refusing to produce his licence when required to do so by inspectors appointed by the commissioners, or by any magistrate or peace-officer, or by any person to whom he shall offer goods for sale, is liable in each case to a penalty of 10*l.* A person having a licence, and hiring or lending it to another person for the purpose of trading with it, and also the person who so trades with another's licence, are each liable to a penalty of 40*l.* A hawker or pedlar dealing in or selling any smuggled goods, or knowingly dealing in or selling any goods fraudulently or dishonestly procured, forfeits his licence, and is for ever afterwards incapacitated from obtaining or holding a new licence. By the stat. 48 Geo. III., c. 84, s. 7, if any hawker or pedlar shall offer for sale tea, brandy, rum, Geneva, or other foreign spirits, tobacco, or snuff, he may be arrested by any person to whom the same may be offered, and taken before a magistrate, who may hold him to bail to answer for the offence under the excise laws.

By the stat. 6 Geo. IV., c. 80, any person hawking any spirits may be arrested, and upon conviction before a magistrate, incurs a forfeiture of the spirits, and may be sentenced to pay a penalty of 100*l.*, and in default to undergo three months imprisonment with hard labour.

By the provisions of the statutes 29 Geo. III., c. 26, s. 6, and also of 50 Geo. III., c. 41, s. 7, no person coming within the description of a hawker or pedlar can lawfully, either by opening a shop and exposing goods to sale by retail in any place in which he is not a householder or resident, other than in a legally established public market during market hours, or by any other means, sell goods either by himself or any other person by outcry or auction, under a penalty of 50*l.*

It is further provided by the 18th section of the 50 Geo. III., c. 41, that, if any person shall forge or counterfeit any hawker's or pedlar's licence, or travel with, or produce, or show any such forged or counterfeited licence, he shall forfeit the sum of 300*l.*

PEERS OF THE REALM are persons to whom the law and constitution attribute certain high dignities and privileges. Without meaning to decide the question whether lords spiritual are in strictness peers of the realm, the persons who fall under this description are the dukes, marquesses, earls, viscounts, and barons, and this without reference to the accident of age, an earl being as much a peer of the realm, though a minor, and consequently not admissible to some of the high privileges of his order. Ladies may also in certain cases be peeresses of the realm in their own right, as by creation, or as inheritors of baronies which descend to heirs general. The wives of peers are peeresses of the realm, and entitled, in consequence of the rank, to certain privileges.

Under the several articles DUKE, MARQUESS, EARL, VISCOUNT, and especially BARON, will be found certain observations pertaining to each distinct order of peers. On the remote origin of this order, and of the privileges belonging to it, especially that great privilege of forming a distinct and independent branch of the legislature, and being at the same time the highest and last court of appeal, great obscurity rests, as it does indeed on the whole of the early constitution and history of Parliament. [PARLIAMENT.] The reports of the committee of the House of Peers, which sat during several parliaments about the years 1817, 1818, and 1819, on the dignity of a peer of the realm, contain a great amount of information on these topics, but leave undecided some of the more important questions connected with it.

It is now, however, clearly established, as a part of the laws and constitution of the realm, that every peer, of full age and of sound mind, is entitled to take his seat in the House of Peers and to share in all the deliberations and determinations of that assembly; and that he has privilege (perhaps not very distinctly defined) of access to the king or queen regnant to advise concerning any matter touching the affairs of the realm. These are great and eminent privileges, but they are accompanied by others which illustrate the great consequence and deference which the constitution of England allows to the possessors of this dignity. If charged with any crime, they are not subject to the ordinary tribunals, but the truth shall be examined by the peers themselves; they cannot be arrested in civil cases; a peer's affirmation on honour is sometimes accepted where in ordinary cases an oath is required; and scandals concerning them are peculiarly punishable.

It is now also clearly established that the crown may at its pleasure create a peer—that is, advance any person to the dignity, and to any one of the five orders; but that when once advanced the peer cannot be deprived of the dignity, or any of the privileges connected with it, except on forfeiture of the dignity in due course of law; and the dignity must descend, on his death, to others (as long as there are persons within the limitation of the grant), with all the privileges appurtenant to it, usually to the eldest son, and the eldest of that eldest son in perpetual succession, and so on, to the eldest male representative of the original grantee. Some deviation from this rule of descent, however, has occasionally occurred, special clauses having been introduced into the patent, which is the writing by which the crown declares its will in this particular, limiting the descent of the dignity in a particular way, as in the case of the creation of Edward Seymour to the dukedom of Somerset, in the reign of Edward VI., when it was declared that the issue of the second marriage of the duke should succeed to the dignity in preference to the son of a former marriage. But generally, and perhaps universally for the two last centuries, the descent of a dignity has been limited to the next male heir of the blood of the person originally ennobled; sometimes with remainders to the next male heir of his father or grandfather. There is an instance in the reign of Charles I. of a dignity of peer of the realm being granted to a person (a Lucas) and the heirs male of his body, with remainder to a brother and the heirs male of his body, with remainder to one who was an illegitimate son of the father of the grantee, and therefore, in the eye of the law, not of the blood of the grantee and the heirs male of his body.

It has not unfrequently happened that the crown has granted the dignity of the peerage to a person, with remainder to the female issue or to the female kindred of the grantee and their heirs, as in the case of the Nelson peerage. In these cases it has generally happened either that the party had no male issue to inherit, and that the other males of the family were also without male issue, or that there was already a dignity inheritable by the male heir of the party on whom a new dignity was conferred to descend to his female issue.

The peers who possess what are called baronies in fee are the descendants and representatives of certain old families for the most part long ago extinct in the male line, but which had in their day summons to parliament as peers, and whose dignity it has been assumed descended like a tenement to a daughter, if only one daughter and heir, or to a number of daughters as co-heirs, when there was no son. This principle has been so often recognised, that it may be regarded as a part of the constitution of the peerage; and in virtue of it, if A die seised of a barony in fee, leaving B a daughter and only child and M a brother, the dignity shall inhere in B in preference to M, and shall descend on the death of B to her eldest son. In case A, instead of leaving B his only daughter, leave several daughters, B, C, D, &c., and no son, the dignity shall not go to M, but among the daughters; and since it is imparticipable, it is in a manner lost as long as those daughters, or issue from more than one of them, exist. But should those daughters die with only one of them having left issue, and that issue a son, he shall inherit on the death of his aunts. This is what is meant by the dignity of a peer of the realm being in *abeyance*; it is divided among several persons, not one of whom possessing it wholly, none of them can therefore enjoy it. [PARCENERS.] But the crown possesses the power of determining the abeyance; that is, it may declare its pleasure that some one of the daughters, or the eldest male representative of some one of the daughters, shall possess the dignity, as would have been the case had there been a single daughter only; and in case of an heir thus entering into possession of the dignity, he shall take that precedence among the barons in the House of Peers which belonged to the family of whom he is the representative. A female who is only a co-heir of a co-heir may also have the abeyance determined in her favour.

Many of the peers, having a superior title limited to heirs male, have baronies in fee inherent in them; so that if A, one of them, die, leaving a daughter, an only child, and a brother, the brother shall take the superior title, and the barony descend to the daughter and the heirs of her body. An eldest son of a peer enjoying a barony and a superior dignity is sometimes also called to the House of Peers in his father's barony. When this is done, it is by writ of summons without a patent of creation (it not being in fact a creation of a new dignity, but only in anticipation of the son's possession of it), and this is the case also when a barony is taken out of abeyance.

Thus the English portion of the House of Peers, or House of Lords, for they are terms used in precisely the same sense, are the lords spiritual—that is, the archbishops and bishops—and the lords temporal, who are of one of the five orders (though many of the dukes possess dignities of the four inferior kinds also, and their ancestors may have long had seats in that house in those inferior dignities before the family was raised to the dukedom), and these are either persons who have been created peers by the crown, who have been admitted into the peerage by favour of the crown in virtue of the determination of an abeyance, or who have inherited the dignity from some ancestor on whom it had been conferred.

The fullest information on all points connected with the antiquarian part of this subject is to be obtained from the Reports of the Committee of the House of Lords before referred to. Biographical accounts of the more eminent of the persons who have possessed these dignities are to be found in that very valuable book, Dugdale's 'Baronage of England.' In 1708, Arthur Collins, a London bookseller, published in a single volume an account of the peers then existing and their ancestors, a work of great merit. The demand for it appears to have been great, as it was followed by other editions in quick succession. It assumed a higher character in 1734, when it appeared in four octavo volumes, great additions having been made to every article. From that time there has been a succession of editions, each professing to be improvements on the preceding, and each bringing up the state of the peerage to the time when the work was printed. But as titles become extinct, and consequently the families bearing them are left out of the peerage-books, those who wish to possess a complete account of those eminent persons must procure many of the earlier editions of the work, as well as that which, being the latest, will for the most part be called the best. There are certain minor works giving the genealogical details of the descent of the dignities, which are published almost every year; but they do not possess the authority of the older works, being too courtly in the manner of their compilation to state the *whole* truth.

PE'GASUS, one of the old constellations, called by Aratus (and also by Hyginus) simply the Horse. The mythological accounts of Pegasus (a son, it was said, of Neptune and the Gorgon Medusa, though how with such parentage he came to be a horse is not stated), the creator of the fountain Hippocrene at one kick, are more than usually unconnected, and the constellation is not a whole horse, but only the head, fore legs, and shoulders, to which a pair of wings is attached; nor is there any fountain near the place, except that with which Aquarius feeds one of the fishes. The figure of Pegasus is inverted, the head being farther from the north pole than the body: the constellation is surrounded by Cygnus, Equuleus, Aquarius, Pisces, and Andromeda. There are three bright stars, α (or Markab), β (or Scheat), γ (or Algenib), which form a rectangular figure with α Andromedæ, such as cannot be mistaken when the latter constellation is known. Moreover a line drawn through α and β points to the pole star, in a line which produced passes through the pointers of the Great Bear.

The following are the principal stars:—

Character.	No. in Catalogue of Flamsteed.	No. in Catalogue of British Association.	Magnitude.
ε	8	7561	2½
κ	10	7571	4
ι	24	7706	4
θ	26	7728	4
ζ	42	7908	3
η	44	7923	3
λ	47	7945	4½
μ	48	7958	4
β	53	8032	2
α	54	8034	2
γ	88	26	2

PEINE FORTE ET DURE. The "strong and hard pain," which is denoted by these words, was a species of torture used by the English law to compel persons to plead when charged judicially with crimes less than treason, but amounting to felony. It was applicable whenever the accused stood mute on his arraignment, either by his refusal to put himself upon the ordinary trial by jury, or to answer at all, or by his peremptorily challenging more than twenty jurors, which was a contumacy equivalent in construction of law to actually standing mute. This proceeding differed essentially from the "quæstio" in the Roman law, and the torture which generally prevailed in Europe, and which, as connected with the royal prerogative, was also practised in England for several centuries, inasmuch as its object was to force submission to the regular mode of trial prescribed by the law, and not to compel testimony or the confession of a crime.

Much difference of opinion has existed upon the question whether the practice of the peine forte et dure originated with the statute usually called the Statute of Westminster 1 (3 Edw. I., c. 12), or whether it was in use at an earlier period. The latter opinion is maintained by Coke and Hale, but the former is adopted by Staundforde, Blackstone, and Barrington. In a note to Hale's 'Pleas of the Crown,' vol. ii., p. 322, Emlyn says that although the Statute of Westminster 1 speaks of this punishment rather as a thing already known than as a new introduction, there is no notice taken of it in any ancient author, case, or record before the reign of Edward I.; and, on the contrary, he cites two curious records in the reign of Henry III., from which it appears that persons at that time arraigned for felony, and standing mute, were not put to peine forte et dure, but had judgment to be hanged. Upon this point it is worthy of remark that the statute of Edward I. merely directs that "such persons as will not put themselves upon inquests of felonies at the suit of the king shall be put into hard and strong prison (*soient mys en la prisone fort et dure*), as those which refuse to be at the common law of the land;" whereas the judgment of the peine forte et dure, as given in ancient books, contained many particulars of suffering to be imposed on the contumacious prisoner, not mentioned in the statute. Fleta, who must have written about ten years after the date of the statute, describes the judgment to be, that "the party shall be cast into prison and lie upon the bare ground clothed with a single garment and barefooted; that he shall have for his food only three morsels of barley-bread in two days; that he shall not have food every day, but only on alternate days; that he shall not drink every day, but that on the day when he shall have no food, water shall be given him to drink." (Fleta, lib. i. cap. 34.) It certainly seems improbable that all these circumstances should, within a very few years, have been added to the judgment warranted by the statute, if the statute had really been the origin of the practice. Mr. Reeve has plausibly suggested that the only object and effect of the statute was to apply the same compulsory process to those who refused to submit themselves to trial by jury in indictments at the king's suit, which had been previously used to compel persons to put themselves upon ancient methods of inquiry, namely, the duel, the ordeal, or the wager of law. ('Hist. of the English Law,' vol. ii., p. 137.) The trial by jury had no doubt been much encouraged during the reign of Henry III., in opposition to the barbarous modes of trial previously used; and it is therefore by no means improbable that this statute should have contemplated the promotion of this great judicial improvement. The language of the enactment also is entirely consistent with the view of its object suggested by Mr. Reeves. On the other hand it must be acknowledged that the instances above mentioned, as cited by Emlyn, and the total silence of Glanville and Bracton, as well as of the judicial records anterior to the statute, respecting such a mode of enforcing submission to the law, are adverse to this interpretation. The origin of this rude proceeding must therefore be considered as uncertain.

It appears from Fleta, and also from Britton (c. 22), that the punishment in the reign of Edward I., when the first traces of it in the history of English law appear, consisted merely of severe imprisonment, with a diet barely sufficient to prevent starvation, until the offender repented of his contumacy and consented to put himself upon his trial. A curious charter of pardon in 1357 ('Fœdera,' vol. vi. p. 13), recites that a woman indicted for the death of her husband, having stood mute, had been adjudged "ad pœnam suam, ut dicitur, in quâ sine cibo et potu in artâ prisonâ per quadraginta dies vitam sustinuit viâ miraculi et quasi contra naturam humanam." It appears therefore that at that time the sentence continued to be imprisonment only, and did not authorise the infliction of any further violence. Shortly afterwards, however, the practice of loading the sufferer with weights and pressing him to death appears to have become the regular course. In the Year Book of 8 Henry IV. (1406), the judgment upon persons standing mute, as approved by advice of all the judges, was "that the marshal should put them in low and dark chambers, naked except about the waist; that he should place upon them as much weight of iron as they could bear, *and more*, so that they should be unable to rise; that they should have nothing to eat but the worst bread that could be found, and nothing to drink but water taken from the nearest place to the gaol, except running water; that the day on which they had bread they should not have water, and *e contrâ*; and that they should lie there till they were dead." Thus, although the reporter states in this case that the judgment was formally different, the punishment now became capital, a lingering and painful death being enjoined instead of severe imprisonment to extort submission. There is no trace of any statute or royal ordinance, or of any authority besides this judicial resolution to justify a change in the mode of proceeding so material as to affect the life of the party. The term by which it was denoted was also changed from *prisone* to *peine* forte et dure; and from this period, for more than three centuries, until it was virtually abolished by the stat. 12 Geo. III., c. 20 (1772), *pressing* to death continued to be the regular and lawful mode of execution for criminals who stood wilfully mute upon their arraignment for felony. The press-yard at Newgate at the present day retains its name as derived from this barbarous practice.

Blackstone, after alluding to "the doubts that were conceived of its legality," and "the repugnance of its theory to the humanity of the laws of England," states that the peine forte et dure was rarely carried into practice. It is probable that it was not of frequent occurrence, because with this fearful punishment for contumacy before their eyes men would naturally for the most part (as Hale says) "bethink themselves and plead." It is, however, repeatedly mentioned in the Year Books as an existing proceeding; it is stated as the law of the land by Staundforde, Coke, Hale, and Hawkins, in their several treatises on the criminal law, and the number of the recorded instances in which it is directly or incidentally mentioned seem to show that it was much more prevalent than has been commonly supposed. The motive of the prisoner in standing mute and submitting to this heavy punishment was to save his attainder, and prevent the corruption of his blood and consequent forfeiture of his lands in case he was attainted of felony. In 21 Hen. VI. (1442), Juliana Quicke, who was indicted for high treason in speaking contemptuous words of the king, had the peine forte et dure because she would not plead (Cro. 'Car.' 118); in the margin of an inquisitio post mortem of Anthony Arrowsmith, in 40 Eliz. (1598), are the words "Prest to death" (Surtees's 'History of Durham,' vol. iii., p. 271); and in 1659, Major Strangeways was tried for the murder of John Fussell before Lord Chief Justice Glynn, and, refusing to plead, was pressed to death in Newgate. In the pamphlet which very minutely relates the particulars of this execution, it is stated that the prisoner died in about eight minutes, many people in the press-yard humanely casting stones upon him to hasten his death. (Barrington's 'Antient Statutes,' p. 85, note.) In still more recent times it appears from the Old Bailey Sessions Papers that at the January Sessions in 1720, one Phillips was pressed for a considerable time, until he begged to stand his trial; and at the December Sessions, 1721, Nathaniel Haws continued under the press with 250 lbs., for seven minutes, and was released upon his submission. Mr. Barrington says that he had been furnished with two instances in the reign of George II., one of which happened at the Sussex assizes before Baron Thompson, and the other at Cambridge, in 1741, when Mr. Baron Carter was the judge. (Barrington's 'Antient Statutes,' p. 86.) In these later instances the press was not inflicted until by direction of the judges the experiment of a minor torture had been tried, by tying the culprit's thumbs tightly together with strings. It is said in Kelyng's 'Reports,' p. 27, to have been the constant practice at Newgate in the reign of Charles II., that the two thumbs should be tied together with whipcord, that the pain of that might compel the culprit to plead. The adoption of this course was no doubt dictated by merciful motives, and was intended by the judges to prevent the necessity of having recourse to the peine forte et dure; but it was wholly unauthorised by law. The practice was finally discontinued in consequence of the statute 12 Geo. III., c. 20, which provides that every person who shall stand mute when arraigned for felony or piracy shall be convicted of the same, and the same judgment and execution shall be awarded against him as if he had been convicted by verdict or confession. But the law in this respect has been altered by the statute 7 & 8 Geo. IV., c. 27, a plea of 'not guilty' being entered on the record if the prisoner refuses to plead.

PELAGIANISM. [Pelagius, in Biog. Div.]

PELARGONE. [Pelargonic Group.]

PELARGONIC ACID, $C_{18}H_{17}O_3 + HO$, is found in the oil of *Pelargonium roseum*. It is an acid oily liquid, with a rancid smell. It becomes solid at low temperatures, and its salts form soap. It forms a *Pelargonate of the oxide of Ethyl*, $C_4H_5O + C_{18}H_{17}O_3$, which is an oily liquid of a very peculiar smell. Frankland states that whiskey owes its peculiar flavour to the presence of this compound. It is manufactured for the purpose of giving new whiskey the flavour of old. [Pelargonic Group.]

PELARGONIC GROUP. A family of organic substances [Pelargonic Series] derived from a peculiar acid found in geraniums (*Pelargonium roseum*). The following are the names and formulæ of the principal members of this group :—

Pelargonic acid	$C_{18}H_{17}O_3, HO$
Pelargone	$\left.\begin{matrix} C_{18}H_{17}O_2 \\ C_{16}H_{17} \end{matrix}\right\}$
Pelargonic ether	$C_{18}H_{17}(C_4H_5)O_4$
Chloride of pelargyl	$C_{18}H_{17}O_2Cl$
Pelargyl	$C_{18}H_{17}O_2$

PELARGONIC SERIES. A division of organic bodies in Gerhardt's system of classification. It contains the following three groups :—

Octylic group. Pelargonic group. Sebacic group.

PELARGO'NIUM, the name of a greenhouse plant, not unfrequently confounded with the geranium. There is a large number of genuine species of this genus, chiefly inhabiting the Cape of Good Hope; and as these intermix very readily, a prodigious number of spurious species, as well as acknowledged varieties, have found their way into the writings of systematic botanists. While however science has been embarrassed by this facility of crossbreeding, the gardens have been enriched by crowds of the most beautiful objects, in which the features of their savage progenitors can no longer be recognised; and it is probable that of all the flowers which have been acted upon by the hand of man, the pelargonium is that in which the result has been most striking. The tuberous-rooted sorts are the most valued for the brilliance of their flowers, and they are propagated either by division of the roots, or by cuttings from the plant. Propagation by seed is resorted to chiefly to obtain varieties, in which the form of the flower, the substance of the petals, and the colour, are the objects aimed at. March is a good time for sowing, which should be done in small pots, in a light rich mould mixed with river sand; and in the division by roots the same method may be followed. With cuttings, from the end of February to the end of August, any time will serve, but in the earlier months the pots should have moderate bottom heat; and in the later, and warmer months, they should be well shaded. The cuttings should be made immediately under a bud, they should be placed near the edge of the pot, gently watered, and guarded against damping off. By care and attention to a few simple points of practice, these plants may be cultivated and multiplied by any one who has a greenhouse, and hence they have become universal favourites. Those points are the following, namely: 1, water, 2, warmth, 3, a gentle bottom heat, 4, abundance of air, 5, as much light as the leaves will bear, and 6, a rich soil during the season of growth; and a cool atmosphere, less water, abundance of light, and close pruning afterwards.

PELARGYL. [PELARGONIC GROUP.]

PELASGI (Πελασγοί) were the most ancient inhabitants of Greece, as far as the knowledge of the Greeks themselves extended; whence they came, or what they really were, is quite unknown. They were one of several races, stated by the Greeks to have been ante-Hellenic, among whom the Leleges are nearest in age and importance to the Pelasgi. The dynasties which include Danaus, Deucalion, and Cadmus, are entirely legendary. There is no doubt there was a people whom the Hellenes styled Pelasgi; but nothing is historically known of them; and it is probable that many of the districts subsequently said to be inhabited by the descendants of the Pelasgi, were merely non-Hellenes, to whom the general term was applied. The whole of Hellas, according to Herodotus (ii. 56), was originally called Pelasgia; and Æschylus ('Supp.,' 250) introduces Pelasgus, king of Argos, as claiming for the people named after him all the country through which the Algus flows, and to the west of the Strymon. We find mention of the Pelasgi in the Peloponnesus, Thracia, Thesprotia, Attica, Bœotia, and Phocis. (Strabo, vii. 321; Herod., viii. 44.) The oracles of Delphi and Dodona were originally Pelasgic (Strabo, ix. 402; vii. 327; compare Herod., ii. 52); and Mr. Clinton ('Fast. Hell.,' vol. i., p. 22) and Niebuhr ('Rom. Hist.' vol. i., p. 27) have adduced reasons for believing that the Macedonians also were a Pelasgic race. We also find traces of the Pelasgi in many of the islands of the Ægean Sea, as Lemnos, Imbros, Lesbos, Chios, &c. (Strabo, xiii. 621); and Herodotus informs us (vii. 95) that the islands were inhabited by the Pelasgic race till they were subdued by the Ionians. The neighbouring coast of Asia Minor was also inhabited in many parts by the Pelasgi. (Strabo, xiii. 621.) The country afterwards called Æolis was occupied by Pelasgians (Herod., vii. 95); and hence Antandros was called Pelasgic in the time of Herodotus (vii. 42). Tralles in Caria was a Pelasgic town (Niebuhr, 'Rom. Hist.,' vol. i., p. 33), and two of their towns on the Hellespont, Placia and Scylace, were still extant in the time of Herodotus (i. 57).

The Pelasgians were also widely spread over the south of Italy; and the places in which they appear to have been settled are indicated by Mr. Malden ('Rom. Hist.') and Niebuhr ('Rom. Hist.').

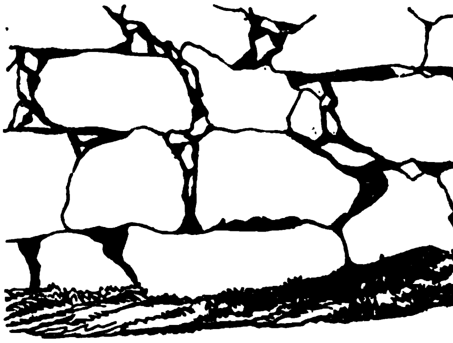
The connection between the Pelasgic and Hellenic races has been a subject of much controversy among modern writers. Many critics have maintained that they belonged to entirely different races, and some have been disposed to attribute to the Pelasgians an Etruscan or Phœnician origin. It is true that many of the Greek writers speak of the Pelasgians and their language as barbarous, that is, not Hellenic; and Herodotus (i. 57) informs us that the Pelasgian language was spoken in his time at Placia and Scylace on the Hellespont. This language he describes as barbarous; and on this fact he mainly grounds his general argument as to the ancient Pelasgian tongue. The ancient writers differ as much respecting the degrees of civilisation which the Pelasgi attained before they became an Hellenic people, as they do respecting their original language. According to some ancient writers (all however only repeating traditions), they were little better than a race of savages till conquered and civilised by the Hellenes; but others represent them, and perhaps more correctly, as having attained a considerable degree of civilisation previous to the Hellenic conquest. Many traditions represent the Pelasgians as cultivating agriculture and the useful arts; and a modern writer (Thirlwall, 'Greece,' vol. i., p. 59) rather fancifully supposes that the most ancient form of their name (Πελασγοί) signified inhabitants or cultivators of the plain.

Some writers have maintained that the Greeks derived the art of writing and most of their religious rites from the Pelasgians; but without entering into these questions, it may be asserted with some degree of certainty that the most ancient architectural monuments in Europe clearly appear to have been the works of their hands; that is, of a race older than the Hellenes. [PELASGIAN ARCHITECTURE.]

(Marsh's *Horæ Pelasgicæ*; Niebuhr's *Hist. of Rome*; Thirlwall's *Hist. of Greece*; Clinton's *Fasti Hellenici*; Grote's *History of Greece*; Wachsmuth's *Hellenische Alterthumskunde*).

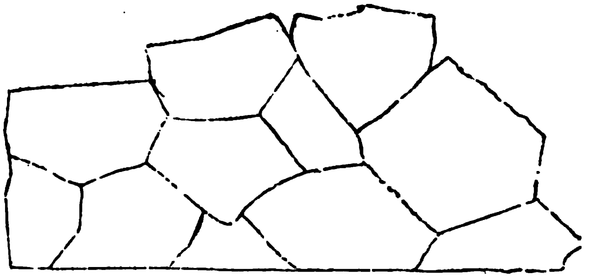
PELASGIAN ARCHITECTURE. The vast masses of unhewn and uncemented masonry forming the walls of Tiryns,—the ancient Tirynthus, about two miles from Nauplia, on the road to Argos,—the oldest human constructions in Greece, were by ancient tradition attributed to the fabulous Cyclopes. They, and similar masses of masonry, have hence come to be generally termed Cyclopean. There can be little doubt that they are of pre-historic date; but they are most probably of Pelasgic origin: the oldest examples of a mode of construction which is found not only in various parts of Greece, but on the western coasts of Asia Minor and in Italy,—wherever, in fact, the Pelasgi settled. [PELASGI.] According to Greek tradition, the walls of Tiryns were built by the Cyclopes for Proetus, as a protection from the attacks of Acrisius; and the date has been, with a vain affectation of precision, fixed at 1379 B.C. All that can with confidence be said of these walls is, that they were in existence when Homer wrote, since he designates Tirynthus as the "well-walled" (Τίρυνθα τε τειχιόεσσαν, 'Il.' ii. 559); and from the mention of them by later Greek writers, and their character, there cannot be any doubt that the existing remains are a portion of the walls referred to by Homer.

The distinguishing character of the walls of Tiryns (and similar walls occur in Lycia), is that they are built of immense polygonal blocks of stone, irregular in size and form, which are laid together with a certain amount of art, and are held in their places by their own weight, no cement of any kind having been employed to fasten them: the interstices between the large blocks are filled by smaller pieces. Some of the largest stones are 9 feet long, 4 feet wide, and nearly as deep; but a more common size is 7 feet by 3 feet.



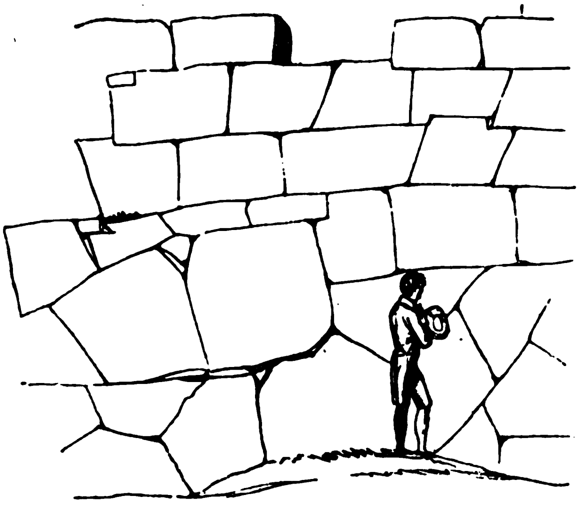
Wall of Tiryns.

At Mycenæ, about 12 miles from Nauplia, are extensive walls by a similar character, and which, like those of Tiryns, were also said of the ancient Greeks to be the work of the Cyclopes; but they, as well as those at Epirus, are obviously of a later date than those of Tiryns, on which they are a marked improvement. In this case, though the blocks are still large, irregular, polygonal masses, they are fitted carefully to each other, and present a smooth exterior surface.



Walls of a Temple at Epirus.

Walls of this kind are found in many parts of Greece, and are of great antiquity. Mycenæ was designated the "well-built" by Homer; but its massive walls were neglected and ruinous when Pausanias and even when Thucydides wrote. A later and more improved style of Pelasgian masonry is that seen in many of the older fortified portions of Greek cities, and in some of the cities of Etruria. In this mode the blocks are still irregular in size, and more or less polygonal, but they are laid with an approximation to horizontality. From this the next step was comparatively easy to the so-called Cyclopean masonry of the ancient Etrurians, which consisted of squared blocks laid without cement in horizontal courses. [ETRUSCAN ARCHITECTURE.] The walls of Cosa, near Orbitella, afford a good example of the latest form of Pelasgic masonry, with, in the upper part, the earliest Etruscan. Cosa, there can be little doubt, was a Pelasgian city before it was colonised by the Etruscans.



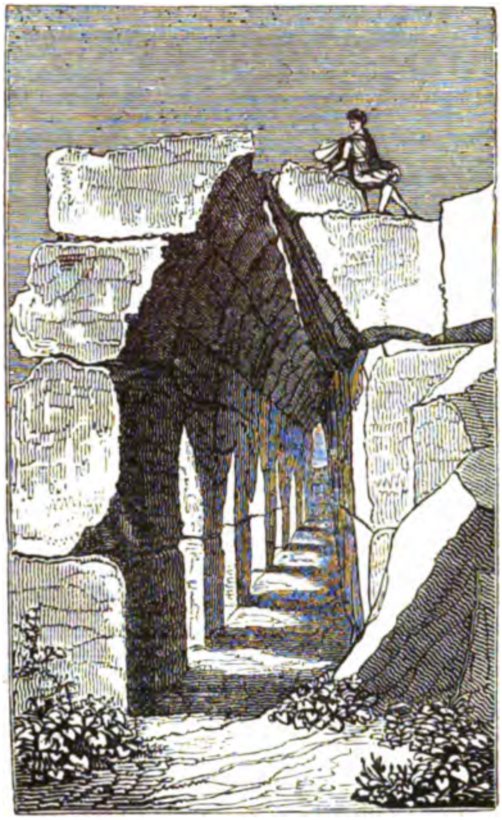
Walls of Cosa.

Of Pelasgian buildings, properly so called, the examples remaining are few, and comparatively unimportant. Of their palaces, which judging from Homer's description of that of Odysseus, and indications in other early writers, must have possessed a certain amount of splendour, no remains exist. They were probably built for show rather than permanency, and may, as has been conjectured, have been constructed chiefly of wood: at any rate they have long perished. Nor are any temples or religious edifices extant. The most remarkable of the existing structures are the subterranean domed buildings called treasuries, but which were more probably tombs, of which that at Mycenæ is the oldest and most important example. This is now usually called the Treasury of Atreus; but its local name appears to be the Tomb of Agamemnon. Constructed under the slope of a hill, the approach to it is by a passage 20 feet wide. The doorway was flanked by highly ornamented semi-columns, portions of which still remain. The interior consists of two domicular chambers. The dome of the largest is 47 feet 6 inches in diameter, and 50 feet high. A doorway leads from it to a smaller chamber, which is about 23 feet in diameter. The domes are formed by horizontal courses of stones, each course projecting beyond that beneath. The walls, of course, gradually approach towards the top, which is closed by a large single slab, thus forming an equilateral pointed instead of a semicircular vault. These are the largest structures of that kind known. The walls of the larger chamber have numerous nail-holes, in horizontal rows, and near the apex of the dome several nails still project from the surface. These are believed to be the fastenings of the brazen plates with which the walls were covered: this being probably one of those "brazen chambers" of which mention is frequently made by Greek writers. The entrance doorway, like nearly all Pelasgian doorways, is formed by two large upright blocks of stone, or jambs, which incline slightly inwards towards the top, and a larger block, or lintel, laid on them. The opening is 18 feet high, 11 feet wide at bottom, and somewhat less at top; the lintel is formed by a block of stone 27 feet long and 16 broad. Over the doorway is a triangular opening. The façade was ornamented with semi-columns and slabs of coloured marbles, with peculiar zigzag carvings in an essentially Oriental style. The characteristic Ionic scroll also occurs. Two similar but smaller and less elaborate structures occur at Mycenæ. Remains of another, known as the Treasury of Minyas, are found at Scripu, the site of the Bœotian Orchomenos; and others in a more or less perfect condition elsewhere.

The walls of Tiryns, of which we spoke above, were a part of the original fortifications, a branch of engineering in which the Pelasgi attained remarkable proficiency, and they are the best remaining example of the fortifications of the heroic ages.

The fortifications occupied the summit of a rocky height (the Acropolis) and covered an area of 660 feet by 180. The walls are in places above 20 feet high, but have been higher; their average thickness is 25 feet. According to Colonel Leake "the fortress appears to have consisted of an upper and lower enclosure, of nearly equal dimensions, with an intermediate platform, which may have served for the defence of the upper castle against an enemy in possession of the lower one."

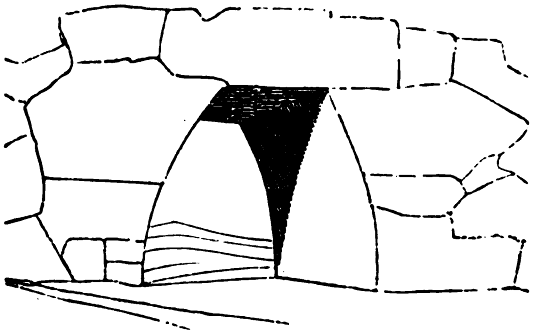
Besides the principal entrance, which was reached by a zig-zag flight of steps, there were postern gates; passages connected the upper and lower fortresses, and there were semicircular bastions and projecting defences with retirements in the walls which served to cover the approaches. But the most remarkable constructive features remaining are galleries formed in the walls; that in the eastern wall consisting of two parallel passages, the centre of which has six recesses or niches in the exterior wall.



Gallery at Tiryns.

"These niches," says Colonel Leake, who brought to his examination of the fortifications professional as well as archæological knowledge, "were probably intended to serve for the defence of the galleries; and the galleries for covered communications to towers or places of arms at the extremity of them. One of these still exists at the south-west angle." These galleries, it will be observed, were formed by making the courses of stones project over each other, the curved form of a pointed arch being given by cutting the inner surface of the projecting stones.

Openings of this form are frequent in doorways and in Pelasgic remains in Italy, as well as in Greece, though no example of a true arch occurs. We give an illustration from Segni in Latium.



Walls and Gateway at Segni.

The fortifications at Mycenæ are even more remarkable from their extent than those at Tiryns. Their builders, as has been mentioned, were said to be the Cyclopes; they were destroyed as far as they could be destroyed by the Argives, 466 B.C. What remains of them consists of an irregular enclosure above 1000 feet long by nearly 700 broad, and in some places 20 feet high. As has been said, the walls exhibit an improvement in structure over those of Tiryns; but the fortifications themselves it is scarcely necessary to say present no architectural character. The only ornamental feature is the great gateway, which is 10 feet high, and at the top 9½ feet wide. It is formed by two great stone uprights or jambs, covered with a lintel 15 feet long, 4 feet wide, and 6 thick. The lintel bears marks of bolts and hinges, and on clearing away the ground in 1842, the ruts formed by the chariot wheels were found in the smooth slabs of the pavement. Above the lintel is a block of gray limestone, 10 feet high and 12 wide, upon which, sculptured in low-relief, is a central column or altar with, on each side, a lion standing on his hind legs and resting his fore-paws on the base; whence it is known as the Gate of the Lions. This is the oldest known example of sculpture in Greece. Pausanius mentions this gateway (B. ii. c. 16) which, he adds, they report was made by the Cyclopes. The lions are carved in a rude but simple style; and in the frieze or altar borne by the central column are rude circular projections which Mr. Fergusson believes represent "the round ends of the timbers of the roof, as if projecting into the frieze."

By the Lernean Marsh, about half a mile from the road from Argos to Mantinea, and a mile from the Erasinos, are the remains of a pyramid crowning a rocky eminence, which some have supposed to be of Pelasgic construction. It is doubtless of extreme antiquity, but whether Pelasgic or not is uncertain: some have seen in it a connecting link with the mythic Egyptian colony of Danaus.

(Leake, *Travels in the Morea; Peloponnesiaca;* Mure, *Tour in Greece;* Sir W. Gell, *Argolis;* Pouqueville, *Voyage dans la Grèce;* Petit-Radel, *Recherches sur les Monumens-Cyclopéens;* Donaldson, *Antiquities of Athens.*)

PELLA'GRA is a disease chiefly affecting the skin, and particularly prevalent amongst the peasantry of the north of Italy. According to Dr. Holland (whose description in the 8th volume of the 'London Medico-Chirurgical Transactions,' is by far the best that has been published in this country), the disease affects the poor almost exclusively, and among them chiefly those who are occupied in the culture of the irrigated rice-grounds, and in other branches of agricultural labour. It usually appears first as a disease of the skin, breaking out early in the spring, with slightly elevated shining dark-red blotches on the hands and feet, and sometimes on other parts of the body, accompanied by a slight pricking sensation. Soon after, small tubercles arise upon the inflamed blotches, and the skin becomes dry and scaly, and often deeply cracked. Desquamation gradually takes place, and, towards the close of the summer, or even earlier, the skin usually appears quite recovered. This, at least, is the usual progress of the first attack; and there is seldom any greater general disturbance of the health than debility, irregular pains of the body, loss of appetite, and emaciation.

In the next spring however the disease usually recurs, with a great aggravation of both the local and the general symptoms, and especially with an increase of the nervous affection, and great anxiety and despondency. In succeeding years it regularly returns with increased severity in every spring, though it does not, as at first, leave the patient nearly healthy in the autumn and winter. After the third attack, or sometimes later, the weakness of the patient commonly becomes extreme, and he has many symptoms similar to those of scurvy, with constant diarrhœa, dropsical swellings, and various nervous disorders. Its most marked character however is the total despair which fills the patients' minds, from which nothing can rouse them, and which, if the disease does not prove fatal by its effects in debilitating their bodies, generally leads to incurable idiotcy or mania. In the lunatic hospital at Milan, Dr. Holland found, among 500 patients, more than one-third in whom the insanity had been the result of pellagra, and "even this statement gives little adequate idea of the nature of its ravages. The public hospitals are far from sufficient to receive the vast number of persons affected with the pellagra; and the greater proportion perish in their own habitations, or linger wretched spectacles of fatuity and decay." The period during which the disease may continue is uncertain; but after the third or fourth year, there is usually little hope of benefit from any means that can be adopted. The diseases to which, in its later stages, it may lead, or with which it may be complicated, are of the most varied kinds; and there are few which, in different cases, the Italian physicians do not ascribe to its influence.

The pellagra prevails chiefly in the provinces of Lombardy between the Alps and the Po, and especially in the district between the Lago Maggiore and the Lago di Como. Among the inhabitants of these parts it has now been supposed to have existed for upwards of a century: here it appears first to have become an object of attention to physicians, and hence to have spread slowly to the Venetian and other northern provinces. It is distinctly an hereditary disease; but there is no sufficient evidence for believing it to be propagated by contagion. Its origin and prevalence are rather to be referred to the condition of poverty in which the peasantry, though the cultivators of one of the most fertile countries in Europe, are compelled to live. Their ordinary diet consists of vegetables, which are usually of inferior quality and ill-prepared: their bread, which is principally made of maize, is for the most part ill-fermented, and often deficient in salt. They rarely have any animal food, and their poverty almost entirely precludes the use of the wines of their own country. Similar wretchedness is evident in their clothing, in their dwellings, and in the deficiency of all the commonest comforts of life. They are thus constantly predisposed to the attacks of diseases of all kinds, and especially are unfit for exposure to the influence of a burning sun during severe agricultural labour. Hence the disease usually makes its first appearance when the peasants are at their most active work, and when the heat of the days is increasing; and hence it is usually first characterised by a disease of the skin, which however is but a slight indication of its future more serious and varied effects.

The treatment of pellagra offers little prospect of success, so long as the patient remains exposed to the same influences by which he was rendered subject to its attack. The course usually adopted by the Italian physicians for the patients who are admitted into the hospitals is a liberal allowance of wholesome food, and the administration of wine and of tonics of various kinds. There seems little reason to doubt that if wholesome food could be constantly secured for the poor, the pellagra would speedily disappear from all the districts in which it now so fatally prevails.

PELLUTEINE. [PELOSINE.]

PELOPONNESIAN WAR is the name given to the great contest between Athens and her allies on the one side, and the Peloponnesian confederacy, headed by Sparta, on the other, which lasted from 431 to 404 B.C. The political state of Greece at the commencement of the war has been briefly described under GREECE, in GEOG. DIV. The war was a consequence of the jealousy with which Sparta and Athens regarded each other, as states each of which was aiming at supremacy in Greece, as the heads respectively of the Dorian and Ionian races, and as patrons of the two opposite forms of civil government, oligarchy and democracy. The war was eagerly desired by a strong party in each of those states; but it was necessary to find an occasion for commencing hostilities, especially as a truce for thirty years had been concluded between Athens and Sparta in the year B.C. 445. Such an occasion was presented by the affairs of Corcyra and Potidæa. In a quarrel which soon became a war between Corinth and Corcyra, respecting Epidamnus, a colony of the latter state (B.C. 436), the Corcyreans applied to Athens for assistance. Their request was granted, as far as the conclusion of a defensive alliance between Athens and Corcyra, and an Athenian fleet was sent to their aid, which however soon engaged in active hostilities against the Corinthians.

Potidæa, on the isthmus of Pallene, was a Corinthian colony, and even after its subjection to Athens continued to receive every year from Corinth certain functionaries or officers (ἐπιδημιουργοί). The Athenians, suspecting that the Potidæans were inclined to join in a revolt to which Perdiccas, king of Macedon, was instigating the towns of Chalcidice, required them to dismiss the Corinthian functionaries, and to give other pledges of their fidelity. The Potidæans refused, and, with most of the other Chalcidian towns, revolted from Athens, and received aid from Corinth. The Athenians sent an expedition against them, and, after defeating them in battle, laid siege to Potidæa (B.C. 432).

The Corinthians now obtained a meeting of the Peloponnesian confederacy at Sparta, in which they complained of the conduct of Athens with regard to Corcyra and Potidæa. After others of the allies had brought their charges against Athens, and after some Athenian envoys, who happened to be in the city, had defended the conduct of their state, the Spartans first, and afterwards all the allies, decided that Athens had broken the truce, and they resolved upon immediate war: king Archidamus alone recommended some delay. In the interval necessary for preparation, an attempt was made to throw the blame of commencing hostilities upon the Athenians, by sending three several embassies to Athens with demands of such a nature as could not be accepted. In the assembly which was held at Athens to give a final answer to these demands, Pericles, who was now at the height of his power [PERICLES, in BIOG. DIV.], urged the people to engage in the war, and laid down a plan for the conduct of it. He advised the people to bring all their moveable property from the country into the city, to abandon Attica to the ravages of the enemy, and not to suffer themselves to be provoked to give them battle with inferior numbers, but to expend all their strength upon their navy, which might be employed in carrying the war into the enemies' territory, and in collecting supplies from the subject states; and further, not to attempt any new conquest while the war lasted. His advice was adopted, and the Spartan envoys were sent home with a refusal of their demands, but with an offer to refer the matters in difference to an impartial tribunal, an offer which the Lacedæmonians had no intention of accepting. After this the usual peaceful intercourse between the rival states was discontinued.

Thucydides (ii. 1) dates the beginning of the war from the early spring of the year 431 B.C., the fifteenth of the thirty years' truce, when a party of Thebans made an attempt, which at first succeeded, but was ultimately defeated, to surprise Platæa. The truce being thus openly broken, both parties addressed themselves to the war. The Peloponnesian confederacy included all the states of Peloponnesus, except Achæa (which joined them afterwards) and Argos, and without the Peloponnesus, Megaris, Phocis, Locris, Bœotia, the island of Leucas, and the cities of Ambracia and Anactorium. The allies of the Athenians were Chios and Lesbos, besides Samos and the other islands of the Ægean which had been reduced to subjection (Thera and Melos, which were still independent, remained neutral), Platæa, the Messenian colony in Naupactus, the majority of the Acarnanians, Corcyra, Zacynthus, and the Greek colonies in Asia Minor, in Thrace, and Macedonia, and on the Hellespont. The resources of Sparta lay chiefly in her land forces, which however consisted of contingents from the allies, whose period of service was limited; the Spartans were also deficient in money. The Athenian strength lay in their fleet, which was manned chiefly by foreign sailors, whom the wealth that they collected from their allies enabled them to pay.

Thucydides informs us that the cause of the Lacedæmonians was the more popular, as they professed to be deliverers of Greece, while the Athenians were fighting in defence of an empire which had become odious through their tyranny, and to which the states which yet retained their independence feared to be brought into subjection.

In the summer of the year 431 B.C., the Peloponnesians invaded Attica under the command of Archidamus, king of Sparta. Their progress was slow, as Archidamus, their commander, appears to have been still anxious to try what could be done by intimidating the Athenians before proceeding to extremities. Yet their presence was found to be a greater calamity than the people anticipated; and when Archidamus made his appearance at Acharnæ, they began loudly to demand to be led out to battle. Pericles firmly adhered to his plan of defence, and the Peloponnesians returned home. Before their departure the Athenians had sent out a fleet of one hundred sail, which was joined by fifty Corcyrean ships to waste the coasts of Peloponnesus; and towards the autumn Pericles led the whole disposable force of the city into Megaris, which he laid waste. In the same summer the Athenians expelled the inhabitants of Ægina from their island, which they colonised with Athenian settlers. In the winter there was a public funeral at Athens for those who had fallen in the war, and Pericles pronounced over them an oration, the substance of which is preserved by Thucydides (ii. 35-46).

In the following summer (B.C. 430) the Peloponnesians again invaded Attica under Archidamus, who now entirely laid aside the forbearance which he had shown the year before, and left scarcely a corner of the land unravaged. This invasion lasted forty days. In the meantime a grievous pestilence broke out in Athens, and raged with the more virulence on account of the crowded state of the city. Of this terrible visitation Thucydides, who himself was a sufferer, has left a minute and apparently faithful description (ii. 46, &c.). The murmurs of the people against Pericles were renewed, and he was compelled to call an assembly to defend his policy. He succeeded so far as to prevent any overtures for peace being made to the Lacedæmonians, but he himself was fined, though immediately afterwards he was re-elected general. While the Peloponnesians were in Attica, Pericles led a fleet to ravage the coasts of Peloponnesus. In the winter of this year Potidæa surrendered to the Athenians on favourable terms. (Thucyd., ii. 70.)

The next year (B.C. 429), instead of invading Attica, the Peloponnesians laid siege to Platæa. The brave resistance of the inhabitants forced their enemies to convert the siege into a blockade. In the same summer an invasion of Acarnania by the Ambracians and a body of Peloponnesian troops was repulsed; and a large Peloponnesian fleet, which was to have joined in the attack on Acarnania, was twice defeated by Phormion in the mouth of the Corinthian Gulf. An expedition sent by the Athenians against the revolted Chalcidian towns was defeated with great loss.

In the preceding year (B.C. 430) the Athenians had concluded an alliance with Sitalces, king of the Odrysæ, in Thrace, and Perdiccas, king of Macedon, on which occasion Sitalces had promised to aid the Athenians to subdue their revolted subjects in Chalcidice. He now collected an army of 150,000 men, with which he first invaded Macedonia, to revenge the breach of certain promises which Perdiccas had made to him the year before, and afterwards laid waste the territory of the Chalcidians and Bottiæans, but he did not attempt to reduce any of the Greek cities. About the middle of this year Pericles died.

The invasion of Attica was repeated in the next summer (428 B.C.); and immediately afterwards all Lesbos, except Methymne, revolted from the Athenians, who laid siege to Mytilene. The Mytilenæans begged aid from Sparta, which was promised, and they were admitted into the Spartan alliance. In the same winter a body of the Platæans, amounting to 220, made their escape from the besieged city in the night, and took refuge in Athens.

In the summer of 427 B.C. the Peloponnesians again invaded Attica, while they sent a fleet of forty-two galleys, under Alcidas, to the relief of Mytilene. Before the fleet arrived Mytilene had surrendered, and Alcidas, after a little delay, sailed home. In an assembly which was held at Athens to decide on the fate of the Mytilenæans, it was resolved, at the instigation of Cleon, that all the adult citizens should be put to death, and the women and children made slaves; but this barbarous decree was repealed the next day. [CLEON, in BIOG. DIV.] The land of the Lesbians (except those of Methymne) was seized, and divided among Athenian citizens, to whom the inhabitants paid a rent for the occupation of their former property. In the same summer the Platæans surrendered; they were massacred, and their city was given up to the Thebans, who razed it to the ground.

In the year 426 the Lacedæmonians were deterred from invading Attica by earthquakes. An expedition against Ætolia, under the Athenian general Demosthenes, completely failed; but afterwards Demosthenes and the Acarnanians routed the Ambracians, who nearly all perished. In the winter (426-5) the Athenians purified the island of Delos, as an acknowledgment to Apollo for the cessation of the plague.

At the beginning of the summer of 425 the Peloponnesians invaded Attica for the fifth time. At the same time the Athenians, who had long directed their thoughts towards Sicily, sent a fleet to aid the Leontini in a war with Syracuse. Demosthenes accompanied this fleet, in order to act as occasion might offer on the coast of Peloponnesus. He fortified Pylus on the coast of Messenia, the northern headland of the modern bay of Navarino. In the course of the operations which were undertaken to dislodge him, a body of Lacedæmonians, including several noble Spartans, got blockaded in the island of Sphacteria at the mouth of the bay, and were ultimately taken prisoners by Cleon and Demosthenes. [CLEON, in BIOG. DIV.] Pylus was garrisoned by a colony of Messenians, in order to annoy the Spartans. After this event the Athenians engaged in vigorous offensive operations, of which the most important was the capture of the island of Cythera by Nicias, early in B.C. 424. This summer however the Athenians suffered some reverses in Bœotia, where they lost the battle of Delium, and on the coasts of Macedonia and Thrace, where Brasidas among other exploits took Amphipolis. [BRASIDAS; THUCYDIDES, in BIOG. DIV.]

The Athenian expedition to Sicily was abandoned, after some operations of no great importance, in consequence of a general pacification of the island, which was effected through the influence of Hermocrates, a citizen of Syracuse.

In the year 423, a year's truce was concluded between Sparta and Athens, with a view to a lasting peace. Hostilities were renewed in 422, and Cleon was sent to cope with Brasidas, who had continued his operations even during the truce. A battle was fought between these generals at Amphipolis, in which the defeat of the Athenians was amply compensated by the double deliverance which they experienced in the deaths both of Cleon and Brasidas. In the following year (421) Nicias succeeded in negotiating a peace with Sparta for fifty years, the terms of which were, a mutual restitution of conquests made during the war, and the release of the prisoners taken at Sphacteria. This treaty was ratified by all the allies of Sparta, except the Bœotians, Corinthians, Eleans, and Megarians.

This peace never rested on any firm basis. It was no sooner concluded than it was discovered that Sparta had not the power to fulfil her promises, and Athens insisted on their performance. The jealousy of the other states was excited by a treaty of alliance which was concluded between Sparta and Athens immediately after the peace; and intrigues were commenced for the formation of a new confederacy with Argos at the head. An attempt was made to draw Sparta into alliance with Argos, but it failed. A similar overture subsequently made to Athens met with better success, chiefly through an artifice of Alcibiades, who was at the head of a large party hostile to the peace, and the Athenians concluded a treaty offensive and defensive with Argos, Elis, and Mantinea for 100 years (B.C. 420). [ALCIBIADES, in BIOG. DIV.] In the year 418 the Argive confederacy was broken up by their defeat at the battle of Mantinea, and a peace, and soon after an alliance, was made between Sparta and Argos. In the year 416 an expedition was undertaken by the Athenians against Melos, which had hitherto remained neutral. The Melians surrendered at discretion: all the males who had attained manhood were put to death; the women and children were made slaves; and subsequently five hundred Athenian colonists were sent to occupy the island. (Thucyd., v. 116.)

The fifty years' peace was not considered at an end, though its terms had been broken on both sides, till the year 415, when the Athenians undertook their disastrous expedition to Sicily. [ALCIBIADES, in BIOG. DIV.; SYRACUSE, in GEOG. DIV.] After the failure of that expedition (B.C. 413), the war became on the part of Athens a struggle for existence; but even then she put forth energies which might have saved her, but for her own infatuation and the gold which her enemies obtained from Persia. The events of the war, from this period to the battle of Notium (B.C. 407), have been related under ALCIBIADES, in BIOG. DIV. The Spartans had now, by the aid of Persian gold, obtained a fleet with which they could cope with Athens on her own element. In the year 406, Conon, who had been appointed, with nine other generals, to succeed Alcibiades, was blockaded in the harbour of Mytilene by the Spartan admiral Callicratidas. His colleagues sailed to his assistance, and completely defeated the Spartans in the battle of Arginusæ. The Spartans now made overtures for peace, which were rejected by the Athenians at the instigation of a demagogue named Cleophon.

In the following year (B.C. 405) Lysander was appointed to the command of the Lacedæmonian fleet. [LYSANDER in BIOG. DIV.] He attacked the Athenians at Ægospotami on the Hellespont at a moment when they were off their guard, and entirely destroyed their fleet. This blow in effect finished the war. Lysander sailed to Athens, receiving as he went the submission of the allies, and blockaded the city, which surrendered after a few months (B.C. 404), on terms dictated by Sparta with a view of making Athens a useful ally by giving the ascendancy in the state to the oligarchical party. [ATHENS, in GEOG. DIV.]

The history of the Peloponnesian War was written by Thucydides, upon whose accuracy and impartiality, as far as his narrative goes, we may place the fullest dependence. His history ends abruptly in the year 411 B.C. For the rest of the war we have to follow Xenophon and Diodorus. The value of Xenophon's history is impaired by his prejudices, and that of Diodorus by his carelessness.

PELOSINE ($C_{36}H_{21}NO_6$), *Cissampeline.* The root of the *Cissampelos pareira* contains a peculiar alkaloid, to which these names have been given. It presents the appearance of an amorphous white powder, which is inodorous, but has a sweetish bitter taste. It is insoluble in water, and possesses the same composition as codeine. When pelosine is exposed to moisture, air and light, it becomes yellow, disengages ammonia, and becomes converted into *pelluteine* ($C_{36}H_{19}NO_6$).

PEMPHIGUS is a disease of the skin, consisting of the eruption of one or more rather large blisters, containing serous fluid, and terminating either in thin scales, in superficial excoriations, or in ulceration. The common and most acute form of pemphigus is usually preceded by shivering, and accompanied by slight feverishness; the eruption appears on some part of the body from one to four days after the beginning of the illness, with a pricking sensation and bright redness of the part affected. Within 24 hours afterwards the blisters begin to rise, and increase in size till they are most frequently as large as nuts, but often much larger, and sometimes smaller. They then, after two or three days, burst, and leave the skin raw and painful. A thin scab usually forms over the exposed skin, and after a few days more, drops off and leaves it healthy, but redder, and with a thinner cuticle than natural. The treatment should consist of gentle purgatives, and cooling medicines and diet; the local applications, if any, should be mild dressings, merely for the purpose of defending the raw surfaces from the air and injury. The disease will thus usually run its course to natural recovery.

A more obstinate form is the chronic pemphigus, which occurs in old or very debilitated persons. The blisters appear one after the other, through an indefinite length of time, some breaking out while others are healing or ulcerating or even sloughing. They are so commonly the accompaniments of other more serious disorders, that the local affections of the skin in these cases are seldom the objects of peculiar treatment; if the condition of debility on which they are grafted can be relieved, they also will soon disappear.

A third form is that termed infantile or gangrenous pemphigus. It is entirely confined to children, and especially affects those who are less than five years old. It occurs sometimes as an epidemic, and is very common among the children of the poor in Ireland, where it is known under the name of white blisters, burnt-holes, eating-hive, &c. The blisters in this form are usually succeeded by deep ulcers, which enlarge rapidly and discharge profusely, and have dark livid edges and a remarkable smell. The child at the same time becomes emaciated and weak, and often about the eighth day of the disease sinks into a state of debility which soon terminates fatally.

PEN. This simple but useful little instrument was formerly made of reed; but the quill has been used in this country for the purpose for about five hundred years; and metal is now adopted still more largely.

Quill Pens.—Under FEATHERS an account is given of the mode of preparing goose-quills, up to the point where they pass to the pen-maker. Of the common method of making pens by hand it is not necessary to speak; we shall therefore only say a few words upon the manufacture of "quill nibs." The barrel of the quill in the first place has both ends cut off, and is divided down the centre; the halves are then laid on their convex side and the edges shaved smooth; after this they are divided into three or four lengths each, and the end of each length is made into a pen by a small machine, which at one stroke makes the slit and cuts the shoulders; they are then finished by being nibbed by hand. Small pocket machines are sold by cutlers for making pens on the same principle as that used in the manufacture of the nibs; but they are expensive, and require careful usage, or they soon get out of order.

The pen used for German text, old English, engrossing, and other black hands as they are called, differs in make, but still more in application, from that employed for ordinary writing. The nib is made as broad as the intended thick or down stroke of the writing; and in using it no pressure is required to open the nibs, as in making a thick stroke by the common pen. The only use of the slit is to give greater elasticity to the point, and to form a channel for the ink. For very large writing two other slits are sometimes made, one in each shoulder; a pen made in this manner works more freely, and does not tire the hand so much as if made with one slit only. The fine or up strokes are produced by throwing the pen to one of the angles of its nib, generally that to the left of the hand in writing, by a turn of the wrist, and a practised hand can produce in this manner the finest hair-stroke. These pens are made of the Turkey quill, the goose quill being too weak for the purpose. In making the slit, in all quills, but more particularly in these, it is necessary that they should be well scraped, as the upper surface, being formed of fibres lying in rings around the quill, will otherwise cause the slit to be ragged.

Bone pens are now made to some extent in France; or rather bone nibs, requiring to be fixed into some kind of handle.

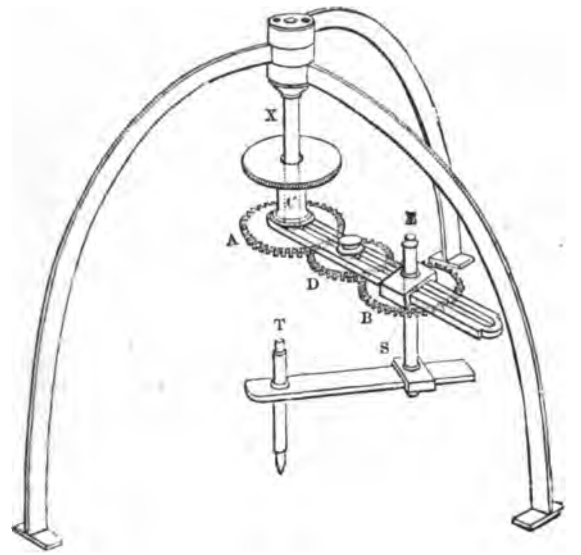
Steel Pens.—Owing to the constant necessity for mending quill pens, the loss of time consequent thereon, and the inequality of the writing, an immense amount of labour and ingenuity has been employed to produce some more durable substitute. The only one, however, which has attained to anything like general use is the steel pen. These pens are manufactured to an amount in quantity, and at a cost so small, as hardly to be credible. Different makers have different modes of operation, but the following will give a general idea of the method employed. In the first place flat pieces of steel are cut out, of the shape required, by a stamping-press; they are then placed under another press, which pierces the holes and cuts the slits; and they are struck into their convex shape by a third press. They are then polished and tempered. The polishing is managed in rather a curious manner: a quantity of pens are shut up in an iron cylinder, leaving a considerable space unoccupied; this cylinder is attached at each end to a crank, the axes of which are connected by a wheel and set in motion by a handle or by machinery. Thus by being rubbed against each other the pens come out well polished, and with all the burrs or sharp angles left by the cutting-presses rubbed smooth. It is impossible to follow with anything like accuracy the amazing spread of this manufacture. Steel pens fell in price from sixpence each to sixpence a dozen; then by degrees to sixpence a gross; and they can now be purchased at fourpence a gross, box included. Some of the largest and finest establishments in Birmingham are for the manufacture of steel pens. Before the general introduction of steel for this purpose, silver was occasionally used, when intended for presents; and brass when intended to accompany cheap brass inkstands, that were made some years ago. Sometimes quill pens were armed with metallic nibs, but this plan was not found to answer; nor was the substitution of tortoiseshell for quill much better. It has been found more practicable, although necessarily costly, to employ small fragments of precious gems for the nibs, and to imbed these in pens made of gold; the gold resists the corrosive action of the ink, while the gem will bear a large amount of work without wearing away. Diamond and ruby have been thus employed. There are also certain rare metals, especially rhodium, occasionally employed for this purpose, on account of their great hardness and durability. Gold pens with rhodium nibs are now made in the following way:—Sheet or plate gold, about $\frac{1}{22}$nd of an inch in thickness, is cut by means of a die into stubs, or small pieces, each piece having a point at one end. A machine then indents the point for the reception of the nib. Small particles of rhodium, as obtained from platinum ores, sometimes sell at prices varying from 10*l.* to 20*l.* per ounce; and one such particle is fastened to the golden point with gold solder. The gold is then rolled to the proper length and thickness, care being taken to have dents in the rollers to accommodate the hard bit of rhodium. The gold, after being hammered to give it elasticity, is cut to the proper shape with a die, stamped with the maker's name and any other device, and turned up to the rounded quill-like form. The rhodium is then split into a nib by a rapidly-revolving copper disc; and another machine extends the slit into the gold. The point is ground on a revolving copper wheel; the gold is made elastic by being rubbed with a small hard stone and water; and the finished pen is finally polished.

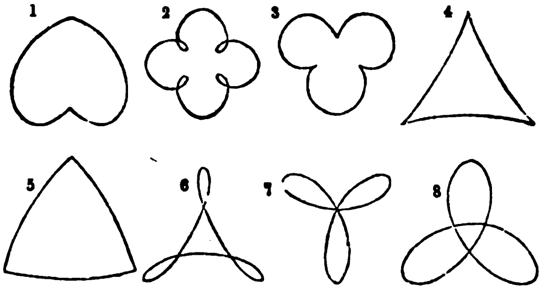
Fountain Pen is a pen made with a reservoir in its stem or holder, to supply ink for some time without replenishing. The nib is in most cases supplied by a small valve, which may be closed when not in use. The varieties are very numerous; but it cannot be said that the plan is successful, for no one variety has obtained an extensive and permanent sale.

Music Pens.—There are two kinds of pen used for the purpose of writing music; the one to rule the lines, and the other to make the dots. The former is a piece of brass with five prongs or points, in each of which is a channel for the ink, which is supplied from a small cup in the solid part of the pen just above the division of the points. The latter is a mere tube with a hole in its side for supplying it with ink, and a small wire or piston fitted within it. The ink flows between the wire and its case, and the dot is made by placing the pen upon the spot, and pressing the wire down upon the paper.

Geometric Pen.—This is an instrument invented by Suardi, an Italian, for drawing geometric curves. These curves may by combination be made to form an almost infinite variety of patterns. The pen is supported, as shown in the diagram, by three legs bowed so as to allow room for the instrument to work within them. These legs shut together by the joint at the top for the convenience of package. Attached to the joint is a stem or axis X, upon the lower end of which is fixed the toothed wheel A; this stem, with its wheel, is stationary, and all the other parts of the instrument move round it. Just above the wheel A is a small tube or cannon, C, to which is attached an arm carrying two boxes and spindles for supporting the wheels D B; the spindle E is continued downwards, and terminates in a socket S, through which passes an arm carrying the pencil or tracer, T. The two wheel boxes, D B, on the one arm, and the socket, S, on the other, may be fixed at any part of their respective arms by means of screws for that purpose. Fixed to the tube C is a small circular plate of metal with a milled edge, by which the instrument is moved around its axis by the thumb and finger.

The sort of curves produced by this instrument depends upon three circumstances: first, the relative size of the wheels A and B; second, whether the wheel D be employed or not, or in other words, whether the two arms move in directions contrary or similar to each other (this wheel has no effect otherwise, and may be of any convenient size); and third, on the relative distance of the tracer T from the spindle E, and of that spindle from the axis X, which may be expressed as the relative distance of TE and EX. The following diagram gives an idea of a few of the most simple curves. The number of parts or leaves in each figure depends on the first of the three circumstances above mentioned: for *fig.* 1 the wheels A and B must be equal; for *fig.* 2, as 4 to 1; and for the rest, as 3 to 1. On the second circumstance depends whether the loops or points are within the curve, as in *figs.* 1, 2, and 3; or on the outer side, as in the others; and lastly, upon the third circumstance depends the shape of the points or loops themselves. For the eight curves given above, TE must be less than EX; but if this is reversed, the curves assume a most curious, complicated, and sometimes beautiful arrangement.





Suardi states that 1273 curves may be produced by the changes of twelve wheels, the smallest having eight, the next sixteen, and so on to ninety-six teeth; and that by the addition of a few pieces, spirals with a circular base, and particularly the spiral of Archimedes, may be produced.

For further information the reader is referred to Suardi's work, entitled 'Nuovo Instrumento per la Descrizione di diverse Curve Antichi e Moderne,' &c.; and to Adam's 'Geometric Essays.'

PENAL SERVITUDE. This punishment has come in place of the former punishment by *transportation*, said to have been first inflicted by stat. 39 Eliz. c. 4. The first act of parliament on this subject is the 18 Car. II. c. 3, s. 2, enabling the judge of assize to transport certain offenders to *America*, there to remain and not to return.

The 22 Car. II. c. 5, s. 4, gave the judges power, "at their discretion," to grant a reprieve, and to cause felons to be transported beyond the seas, there to remain for the space of seven years; but if the offender refused to be transported, or returned within the time, then he was to be put to execution upon the judgment. The 22 & 23 Car. II. c. 7, s. 4, directed a judgment of transportation to be entered, when the felon elected to be transported, and it authorised the sheriffs to cause offenders to be embarked. It also made a return before the expiration of the sentence, a capital felony. The next statute on the subject was the act 4 Geo. I. c. 11, "the foundation of the law of transportation," which enacted that, when the crown should be pleased to extend mercy, upon condition of transportation to any part of *America*, any court, having proper authority to do so, might direct the offender to be transported. The stat. 6 Geo. I. c. 23, again made a person "*at large* in Great Britain, before the expiration of the term" of transportation, liable, on conviction, to suffer death. The 8 Geo. III. c. 15, extended the powers of the judges to make orders for transportation by enabling them to do so out of court; and by the stat. 30 Geo. III. c. 47, the king was empowered to authorise the governors of convict settlements to remit the sentences of transports.

By the stat. 5 Geo. IV. c. 84 (amended by 11 Geo. IV. and 1 Wm. IV. c. 39), consolidating the laws on the subject of transportation, the king in council was empowered to appoint places beyond the seas, to which persons under sentence of transportation should be conveyed, the governor or other person to whom they were delivered, or his assignee, having the property in the service of the convicts. The sovereign was also empowered by warrant to appoint places of confinement at home, either on land or on board vessels in the Thames, or other rivers or harbours, for the confinement of male offenders (extended by the stat. 16 & 17 Vict. to females) under sentence of death, but reprieved or respited, or under sentence of transportation, there to remain under order of the secretary of state until entitled to their liberty, or removed, or otherwise dealt with. The capital punishment for offenders found unduly at large before the expiration of their sentence was subsequently abolished by 4 & 5 Wm. IV. c. 67, which substituted transportation for life, with previous imprisonment not exceeding four years.

New South Wales, Van Diemen's Land, and Norfolk Island, thus became the principal receptacles for convicts. Although the property in the services of these persons was vested in the colonial governor or his assigns, a practice prevailed of granting them, in certain cases and on certain conditions, permission to employ themselves for their own benefit. These permissions were usually called "tickets of leave." By the stat. 6 & 7 Vict. c. 7, the legislature, thinking it just that ticket-of-leave convicts should be protected in their persons, and in the possession of such property as they might acquire by their industry, empowered them to hold personal property, and to maintain actions in respect thereof while such tickets remained unrevoked.

The reception of convicts having, however, become distasteful to the inhabitants of the colonies, the stat. 10 & 11 Vict. c. 67, was passed, permitting offenders under sentence of transportation to be removed to any prison or penitentiary in Great Britain; directors of the principal convict prisons being appointed afterwards under the stat. 13 & 14 Vict. c. 39. The difficulty attending the reception by the colonies of transported convicts having increased, the stat. 16 & 17 Vict. c. 99, finally abolished the punishment of transportation *for less than fourteen years*, and substituted penal servitude at home for certain periods, giving the courts power in all cases to substitute such penal servitude for transportation.

Before this last statute was passed, a system had for some time prevailed with respect to well-conducted convicts (who, although sentenced to transportation, had been kept at home), of granting them free pardons, generally at the expiration of half their sentence of transportation. As the continuance of the same system under the last-mentioned statute seemed likely to cause serious evils, but as it was at the same time desirable to encourage good behaviour in convicts, it was determined to try the experiment of retaining some control over them in cases where they were set at liberty before the expiration of their original sentence. With that view the statute empowers the crown, by order of one of the secretaries of state, to grant any convict a licence or "ticket of leave," to be at large during such portion of his term of transportation or imprisonment, and upon such conditions, as may be thought fit, such licence being also revocable at pleasure.

Finally by the stat. 20 & 21 Vict. c. 3, the sentence of *transportation* is entirely abolished, and the sentence of penal servitude substituted; but the statutes which have reference to transportation are to have reference to penal servitude, so that the name alone is changed.

As to the government of convict prisons in the colonies, see 22 Vict. c. 25.

PENALTY, in its original and proper sense, is a pecuniary punishment imposed by statute upon parties guilty of certain offences. This term is also used to denote a sum of money which a party to a contract has engaged to pay in case he violates his engagement. Penalties imposed by statute are strictly regulated by statute; but with respect to penalties created by contract, the rule is neither so strict nor so uniform. The courts of law will not allow a larger sum to be recovered in the name of penalty than is sufficient to cover the damages actually sustained; but where the parties have determined in advance the damages that shall in certain events be considered to have been sustained, and nothing essentially inconsistent with the reasonableness of such determination appears upon the face of the transaction, the courts do not interfere, and the damages thus pre-determined are recoverable under the name of liquidated damages. Where a penalty is fixed, *eo nomine*, for the breach of an agreement, and yet larger damages are actually sustained, the larger amount may be recovered as damages without recourse to the penalty. In many cases the distinction between a penalty and liquidated damages is often difficult to ascertain, and some of the decisions on this head are not easily reconciled.

Formerly the interference of a court of equity was often necessary to temper the severity of the common law, but by the statute 8 & 9 Wm. III., c. 11, s. 8, it was provided that in actions in courts of record upon any bond or penal sum for the performance of covenants or agreements contained in any indenture, deed, or writing, the plaintiff shall state the breaches of covenant or agreement which he has sustained, and damages are to be assessed accordingly. If the plaintiff recover in the action, judgment is entered up for the penalty, but execution issues only for the damages assessed by the jury upon the breaches stated and proved, the judgment remaining as a security against future breaches of the same covenant or agreement, or of other covenants or agreements contained in the same instrument, and protected by the same penalty. And now there is little if any difference between the practice of the courts of common law and equity upon the subject of penalties. [BOND; DAMAGES.]

PENANCE (in Latin, *Pœnitentia*) is a censure or punishment, enjoined by the ecclesiastical law, for the purgation or correction of the soul of an offender, in consequence of some crime of spiritual cognisance committed by him. Thus a person convicted of adultery or incest was adjudged to do penance in the church or market, bare-legged and bare-headed, in a white sheet, and was required to make a public confession of his crime, and to express his contrition in a prescribed form of words. After a judgment of penance has been pronounced, the ecclesiastical courts may, upon application by the party, take off the penance, and exchange the spiritual censures for a sum of money to be paid and applied to pious uses. This exchange is called a commutation for penance; and the money agreed or enjoined to be paid upon such a commutation may be sued for in the ecclesiastical court.

The *peine forte et dure* imposed upon a person who stands mute on his trial at the common law is often inaccurately termed penance. [PEINE FORTE ET DURE.]

PENATES were Roman deities who were supposed to preside over families and houses. Cicero ('De Nat. Deor.,' ii. 27) derives the word either from *penus*, "food," or *penitus*, "innermost;" but it appears probable that the latter etymology is the more correct. We learn from Festus (*Penus*) that the inner part of the temple of Vesta was called Penus, which seems to be connected with *penates*, *penetrare*, and *penetralia*. The hearth of the atrium was sacred to the Penates; and as this place was the innermost or most important part of the house, it was called the Penetralia. There appears sometimes to have been a kind of recess in the wall, called *sacrarium*, in which the images of the Penates were kept. (Cic. in 'Verr.,' iv. 2; 'Dig.,' i., tit. 8, s. 9.) A fire was always kept burning on the hearth sacred to the penates; a salt-cellar dedicated to them was placed on the dinner-table, and the meal concluded with a libation to them. Every master of a family was the priest to the Penates of his own house.

It is a matter of some difficulty to determine who the Penates were; but there is no reason for believing that they were the same in every family. Some writers have thought the Lares and Penates to be the same, and it would appear that the Lares were included among the Penates. The Lares however were of human origin, and appear to have been regarded by the Romans as the manes of their ancestors [LARES]; while among the Penates we find mention of the superior gods, as Vesta, Jupiter, and Juno. (Festus, s. v. 'Herceus.')

There were also public Penates, who were supposed to have been brought by Æneas from Troy. They were represented as two young men with spears in their hands, and the temple or chapel in which they were worshipped was in the centre of the city, not far from the temple of Vesta. (Dionys., i. 68; Cic., 'De Nat. Deor.,' ii. 27; Liv., xlv. 16.)

(Hartung, *Die Religion der Römer*; Klausen, *Æneas und die Penaten*; Barker, *Lares and Penates*.)

PENCIL, the name given to the small brushes used by artists, whether made of hog's bristles, camel hair, fitch, or sable. The larger brushes are sometimes set in a tin tube, and the smaller in quills of different sizes. The soft pencils for artists are made as follows:—The tail of the animal (sable, badger, marten, &c.) is scoured in a solution of alum; then steeped for several hours in luke-warm water; then dried in linen cloths; and finally combed out regularly. The hairs are seized with pincers, and cut off near the skin; and the little parcels of hair are sorted into groups according to their length. A few hairs are then taken, enough for one pencil, and placed in a little receptacle which holds them while a thread is bound round near the roots. The base of the pencil is then trimmed flat by scissors. The hairs thus prepared are fitted either into quills or into tin tubes. The quills are those of swans, geese, ducks, lapwings, pigeons, or larks, according to the size of the pencil. Each quill is softened and swelled in hot water, and the bunch of hairs is introduced at the larger end, and pulled forward by a simple apparatus to the smaller end, where the shrinking of the quill binds the hairs closely. The great art in pencil-making is so to arrange the hairs that their ends may be made to converge to a fine point when moistened and drawn between the lips; and it is said that females are more successful than men in preparing the small and delicate pencils.

The well-known *Black-lead pencil* is made by cutting "Cumberland lead," or plumbago, into thin plates with a saw, and again into strips as wide as the plate is thick. These strips are then laid in a groove in a piece of cedar, upon which is glued another and thinner piece: the whole is afterwards rounded by a plane adapted to that purpose. Pencils are commonly marked with certain letters to denote the quality of the lead, as H for hard, B for black, M for medium, and so on. Successful attempts have been made to use black-lead powder, mixed with other substances, as a composition for pencils; it is not suitable for fine artistic purposes, but is available for common use.

Other pencils are made of black and coloured chalks for drawing, and are much more convenient than the port-crayon. Several recent kinds are described under CRAYONS.

The ever-pointed pencil is an instrument so simple and so well known as to require little description. The point, or nozzle, is made hollow to receive a small cylindrical piece of black lead, about three-quarters of an inch long, which cannot pass through the lower end without some little force. Within the case is a screw or worm, which, if the case be turned round with one hand while the point of the pencil is held by the other, causes a wire or mandril, about the same size as the lead, to advance or retire. When a fresh lead is put into the point, the case must be turned round towards the left until the mandril is drawn up as far as possible. The point containing the lead is then to be screwed on to the case, and the case being turned gently to the right hand, the lead must be forced forward until it can just be seen at the point. These leads are made of different degrees and sizes, and the cases are marked accordingly. The leads are manufactured in the following manner:—After the plumbago is cut into square strips of the same diameter as, or a little greater than, the lead required, they are passed successively through three ruby holes, each smaller than the preceding. By this means they are rendered perfectly round and smooth, so as to offer no impediment to the working of the pencil. Most cases are made with a reservoir at the top, in which a supply of five or six leads may be carried.

Considerable ingenuity has been displayed within the last few years in the production of these ever-pointed pencils. In some, the small rod of black lead is moved backwards and forwards by the action of a screw, as just described; in some, by a slide; and in others, by percussion. One sort is made of vulcanised india-rubber, with the end having such a nicely adjusted diameter as just to hold the lead steadily, and yet allow it to be moved by a slight percussion. Some of the best acting ever-pointed pencils are now saleable retail at sixpence each, while one particular kind is manufactured to sell retail at so low a price as twopence.

PENCIL, a term of optics, and sometimes of geometry. A pencil of rays is a collection of rays which converge to or diverge from the same point; and a pencil of lines is a number of lines which meet in one point.

PENDENT, or **PENDANT**, in Pointed Gothic architecture, an ornamental mass of stone, hanging down or descending from the intersections of a groined vaulting. Pendents, no doubt, originated in bosses, of which they may be considered an enlargement, and may be described as being of a corbel or bracket shape. They are in England almost peculiar to the Third Pointed or Perpendicular and the cognate domestic or collegiate style, in roofs of fan-work tracery, of which they are highly beautiful features, admitting of great variety of design. The roofs of King's College Chapel, Cambridge, St. George's, Windsor, Henry VII's Chapel, and the Divinity School, Oxford, are fine examples of the effect of pendents. Carved pendents of a different kind were frequently employed for the enrichment of open timber-roofs, but are not similarly applied, being suspended, not from the centre of the roof, but at the extremities of the hammer-beams, from which the ribs of wood-work forming the arches of the roof spring. Of this kind is the roof of the hall of Eltham Palace, and several of the halls of colleges at Oxford and Cambridge.

PENDENTIVE, though often inaccurately used as synonymous with pendent, has quite a different meaning. Strictly speaking, pendentives are the spandrels or triangular spaces between the arches or arch-headed walls, as the case may be, supporting a dome, which is continued down to the springing of such arches; consequently, where the dome rises from the cornice of a cylinder of the same diameter (as in the Pantheon at Rome), there are no pendentives, although there may happen to be arches in the cylindrical or polygonal circumference beneath the cornice. In such case the spandrels, or spaces between the arches are improperly called pendentives, notwithstanding that they sometimes are so, pendentives being those portions of the inner surface of a dome where the latter is intersected by vertical planes, whether produced by voids or solids. Pedentives are of frequent occurrence in Byzantine architecture. In London the dome of the hall or principal office of the London and Westminster bank is a pendentive one.

PENDULUM. Under HOROLOGY will be found some details respecting clock and compensated pendulums, together with figures of the *gridiron* and *mercurial* pendulums. We here insert a few miscellaneous details on the same subject.

The way in which motion is communicated to a pendulum is there described. It may be added that the clasp of the pendulum by the crutch should neither be very close nor very loose, and the axis of motion of the pendulum should be exactly in the continuation of the arbor of the crutch. The clock-frame itself must be firmly fixed, for any shake or looseness of the support of the pendulum will alter its time of oscillation: the bob should be heavy, the arc of vibration small; and when good performance is required, the rod should be of deal, well varnished or gilt. Iron-wire makes the next best rod, and brass the worst. Whenever a brass rod is used for an ordinary clock-pendulum, the maker is not master of his craft, or he thinks little of his customer's knowledge. The errors arising from changes of temperature when deal, steel-wire, and brass are used, are as 1, 3, and 5. It must however be remembered, that unless the deal rod pendulum be coated over, so as to be impervious to moisture, it will be liable to small errors arising from that cause. A range of 50° will not alter the rate of a clock with a white deal pendulum more than 5^s a day, if Capt. Kater's value of the expansion of deal be correct.

In a well-made clock, the error arising from expansion from temperature is the most considerable, and is that which must be guarded against. Mr. Baily's contrivance with a leaden weight is given under HOROLOGY. We may add that a lenticular form may be given to the weight, provided the proper length be preserved, and this will be an improvement, as it diminishes the resistance of the air, and the error which arises from the inertia of the air carried by the pendulum.

It is stated in the article just referred to, that in Harrison's pendulum foreign artists use zinc rods instead of brass. Zinc is objectionable as being a weak metal, and it is said by some persons to expand by jumps, which seems not very probable unless much exposed. The great objection to the gridiron pendulum is that the astronomer, if he be no workman, must rely upon the artist for perfect compensation (and this is perhaps never achieved); and again, if from rust or bad fitting the slipping parts should bind, the action will necessarily be by bounds and irregular. After the clock-maker has done his best, a year's experience will point out the error in the compensation, which can easily be remedied, if the fault be over-compensation, by cutting the zinc rods shorter. All the fixed parts should then be secured as firmly as possible by steady pins, as any attempt to reserve a power of further adjustment would be too dearly purchased by a ricketty frame. The bands attached to rods 1 and 5 for the purpose of keeping the zinc rods in their places should not squeeze the zinc; and but just press against them with the spring of the metal. Harrison is said, by Short ('Phil. Trans.,' vol. 47, p. 517), to have invented his pendulum about 1725.

The construction of Graham's pendulum allows the astronomer to alter and finally perfect the compensation. This quality, and the absence of any nice fitting or slipping parts, give Graham's construction a very decided superiority over Harrison's, especially for a clock which is not to be moved from place to place. These mercurial pendulums are generally constructed in a more expensive manner than is necessary. The vertical rods may all be made of stout steel wire, and the base and top of the stirrup of brass. Mr. Baily, in his valuable memoir ('Astron. Soc.,' vol. i.), justly recommends that the thread of the regulating screw should be deeper and coarser than it is usually made, and be tapped on a stouter cylinder. Graham's pendulum is described by himself. ('Phil. Trans.,' vol. xxxiv. p. 40.) It was invented in 1722. There are many ways of compensating a pendulum for the effects of temperature, some of which are very ingenious, and others very simple. Those described under HOROLOGY will suffice for an explanation of the principle; they are the most usual, the most easy of execution, and most exact in their operation.

The superiority of detached escapements has been noticed under HOROLOGY. In those in ordinary use, time and dirt and thickening of the oil not only affect the amount of the impulse, which is comparatively of slight moment, but the continuing action of the teeth on the pallets is also irregular. The space through which the pendulum swings, or *arc of vibration*, is thus liable to variation, which again produces a change in the time in which each oscillation is performed, that is, if the pendulum be supposed to oscillate round a fixed axis. This inequality was more apparent in the early clocks, where the pendulum was light and the arc of vibration very large, than in those of modern construction, where the pendulum is heavy and the arc small. Huyghens's remedy of cycloidal cheeks is noticed under HOROLOGY. It is said by all later writers on the subject that the remedy is worse than the disease; and it is possible enough that something like sticking between the flexible top and the cycloidal cheek may take place at the critical point, that is, just when the pendulum has arrived at the end of its swing, and is pausing for its return; and that there may be a difficulty in making and setting the cheeks so truly as to act on the pendulum in every part of its swing. A second objection is alleged against Huyghens's cheeks—namely, that, as the pendulum cannot be considered to be a heavy point suspended by a rod without weight, the centre of oscillation shifts *downwards* as the flexible portion of the top wraps on the cheek. This objection might be easily got over by making the cheeks not truly cycloidal, but of such a form that the centre of oscillation of the compound pendulum shall oscillate in a cycloid, which would be easy enough when the form of the pendulum was given. In truth this is a matter of mere speculation in astronomical clocks, for there is a much easier way of producing sensible isochronism in them, which we will describe; but we suspect that the cycloidal cheeks might still be used advantageously in clocks which resemble Huyghens's, as the Dutch clocks which are in common use.

Instead of suspending the pendulum by a perfectly flexible string, or on a knife-edge, when the motion must be in a circle, the top of the rod ends in a flat spring. (See *Figs.* 20, 21, under HOROLOGY, where the spring is seen in front, like a fine line, at the top of each pendulum.) This produces two effects upon the time of oscillation: first, by retarding the motion of the pendulum in its rise and accelerating its fall, the spring shortens the time of vibration, and the more the stronger it is; but as its action at each point is nearly proportional to the degree in which it is bent, that is, as the arc of vibration reckoned from the position of rest, this action will have no tendency to alter the isochronism of unequal arcs. The bending of the spring has however a second effect, that of causing the bob of the pendulum to describe a curve which is not circular, but which falls within a circle; and this, by proportioning the strength of the spring to the weight of the pendulum, may be made to approach to Huyghens's cycloid, or to that modification of it which we have described. It is possible to select a spring of such strength as shall completely satisfy this condition, at least within the necessary limits, that is, for such variations in the moving power as arise from dirt, thickened oil, and wear in the works.

Frodsham's experiments on suspending springs are also noticed under HOROLOGY. In no case does Mr. Frodsham seem to have found a spring which caused the clock to *gain* in the larger arcs, which, on the information of other makers, and on theoretical grounds, we consider possible. With a spring stiffer than that which was isochronous, Mr. Frodsham found that using as effective lengths 0·97, 0·66, and 0·50 of an inch, the change of rate produced by using 4lb. 1oz. as the weight, instead of 2lb. 2oz., was to give the clock a losing rate of $3\cdot7^s$, $2\cdot6^s$, and $3\cdot5^s$, respectively. The law is not apparent, and it would seem that, even with this spring, shortening the spring had no sensible effect. Another remark of Mr. Frodsham's, which is very valuable if it be confirmed by extended trials, is, that the spring which produces isochronism is also the spring with which the pendulum, unattached to any clock, will keep up its motion for the longest time. It seems to us probable that this latter quality will belong to the weakest spring which preserves its full elasticity under the pull of the bob; for if the elasticity were perfect, the only cause of loss of motion would be the resistance of the air, which is not sensibly altered by the effect of the spring. However this may be, the subject is well worth further consideration. Notwithstanding the care bestowed by Mr. Frodsham, it is difficult to conduct inquiries of such nicety with an uncompensated pendulum. It will also be necessary, as we shall now point out, to attend to the state of the barometer when the experiments are in progress. For when the effect of the air upon the time of oscillation of a pendulum is examined, it will be found that the *resistance* of the air has no influence except the indirect one of shortening the arc of vibration, that is, of tending to make the clock gain, if the bob move in a circular arc. The *buoyancy* of the air acts more immediately, for it diminishes the *weight* of the pendulum, and leaves the *inertia* unaltered, and therefore diminishes the accelerating force. Hence a greater density in the air acts as a diminution in the force of gravity, that is, makes the clock go slower. The effect is greater indeed than was at one time anticipated; for, as was remarked long ago by Du Buat, and subsequently shown by Bessel, the pendulum must be considered to include in its inertia a small wrapper of air which is involved in it or accompanies it in its course. (See a very elaborate and valuable memoir by Mr. Baily, 'On the Correction of a Pendulum for the Reduction to a Vacuum,' 'Phil. Trans.,' 1832, p. 399.) This latter portion of the effect of the air depends on the form of the pendulum, and possibly may even be affected by the polish of its surface. Now, the density of the air is proportional *directly* to the pressure of the atmosphere shown by the barometer, and *inversely* to the temperature, which is known from the thermometer. The latter portion might be practically included in the general compensation for temperature, but the former requires either a specific and peculiar compensation, or may be determined as a residual quantity, and tabulated for each clock with the mean height of the barometer for the period required. Dr. Robinson's investigation on the effect of atmospheric pressure on the rate of a transit clock is referred to under HOROLOGY. The compensation for the variation of atmospheric pressure was made by attaching small barometers to the pendulum rod, but we believe this ingenious idea was not attended with any practical benefit. It would perhaps be possible so to balance some of these contending principles as to obtain a performance nearly perfect; thus an arc of vibration might be selected in which the increased density of the air, by reducing the arc, might accelerate the time of an oscillation as much as the increased buoyancy and inertia would retard it, or so nearly so, that the remaining difference might be completely annihilated by a proper selection of the pendulum spring. But even if this should be effected, and we see no obstacle to it except the time and trouble it would require, any change of the moving power, or of the action of the escapement, would alter the arc and derange the equilibrium. As the effect of time is generally to produce a falling off in the arc, a small addition to the clock weight might be made from time to time, so as to bring back the pendulum to its primitive arc, until the clock is cleaned, and its action restored that way. We shall conclude this long disquisition (which we propose for consideration until decisive experiments are made) by a piece of advice which we can warrant. Where the clock is much exposed to variations of temperature, enclose it in a second covering or closet. This will protect it from injury, and moreover will very much regularise the rude transitions of temperature to which clocks are in this climate liable. It is not improbable that the parts of a clock, and of its pendulum, if much exposed, may take their temperature at different times, and if so, the compensating principle is not brought into action, but must act irregularly.

It has already been said that a clock, to go steadily, should be securely fixed. The common mode is to fasten the case by strong bolts, under the rising board and again about as low as the pendulum bob, to a stone pillar or through a wall. The pendulum is generally suspended from a cock on the back of the frame, but it may be supported on a triangle standing on the rising board, or even from the back of the case, but there is then a fear that the axis of motion may not be in the axis of the pallets, or may not keep so. The clock being fixed, the first step is to put it *into beat*, that is, to make the beats follow at equal intervals. The clock-maker does this in common clocks by bending the crutch, but when the discrepancy is not great, any one may produce the desired equality by tilting the frame a little; in table-clocks there are generally footscrews for the purpose, or if not, the feet may be propped by pieces of wood, card, &c. In astronomical clocks, the angle which the crutch makes with the pallets admits of a small adjustment by two screws, which act on opposite sides of the crutch, and the operation is performed as follows:—Make the beats nearly correct by ear, and by touching the screws: note which screw belongs to the longer leg; then by softly deadening the pendulum as it rises, make it just *not* escape on one side. By very gentle pushes cause it to escape on that side, and see whether it escapes on the other; if it does not, one screw must be screwed up and the other released. After a few trials and errors it will be found that when the pendulum just escapes on either side, it will just escape on the other, and if there be a very small inequality indeed, a little tightening of one of the crutch screws will complete the adjustment. The pendulum should then be brought to rest, and the zero of the plate on which the arc of vibration is read off, be fixed just behind the pointer of the pendulum, shown at O, *figs.* 20, 21, in HOROLOGY. In that article the rule for bringing a clock to time is given.

In an observatory it is always desirable that a clock should have a small losing rate, and be slow rather than fast (the corrections for clock error and clock rate are then additive), so that it would be better to add a smaller weight than 46 grains; and in any case it is more safe to destroy the rate by two operations, especially if the preceding rates were not very carefully determined.

The final adjustment of the compensation can be best accomplished when the clock has gone several months, and when the gain or loss in two of the warmest months in the year is compared with the gain or loss in two of the coldest. Suppose the *mean* temperature in the summer months of trial to be 30° higher than in the winter months, and that the clock loses 1^{s} more in summer than in winter; it is therefore *under-compensated*, and requires more mercury. Add 1 lb. of mercury, and bring it to a close rate exactly as before; and now let it be *over*-compensated, so that an increase of 24° in the temperature causes it to gain $0^{s}{\cdot}4$ per day, which, by simple proportion, is the same as a gain of $0^{s}{\cdot}5$ by 30° of temperature. Hence it is clear that as 1 lb. of mercury causes an alteration of $1^{s}{\cdot}5$ in the variation due to temperature, if a third of a pound be withdrawn the compensation will be nearly correct. A second trial will perfect the compensation, which should never be afterwards disturbed.

The researches respecting resisting media have already been referred to. There existed for some time a discrepancy between Poisson's factor, by which the correction for buoyancy is to be multiplied, to give the whole effect observed, and Mr. Baily's: the one being 1·5, and the other 1·8. Professor Stokes has reviewed the subject in a memoir published in the 'Transactions of the Cambridge Philosophical Society.' In this inquiry the internal friction of the fluid or medium is taken into account. In the case of a ball-pendulum the resistance is proportional, not to the surface, but to the radius of the sphere, so that the quotient of the resistance divided by the mass increases very rapidly as the radius decreases. Hence the terminal velocity of a minute globule of water, descending through the air, depends almost entirely on the internal friction of air; but since the index of friction is known from Baily's experiments this terminal velocity can be calculated numerically for a globule of given diameter. This velocity is so small in the case of globules, such as those of which clouds are probably formed, that according to Mr. Stokes, the suspension of clouds need not offer any difficulty.

When a pendulum is not limited to one plane, but only to the concave surface of a hollow sphere, we have what is called the *conical* pendulum. Its motions have of late years been investigated in the pages of the 'Philosophical Magazine,' and elsewhere.

Length of Simple and Invariable Pendulum.—The equality of the oscillations of a weight suspended by a line is said to have been used by Ibn Junis, in 1100, and by the Arabian astronomers, for the subdivision of portions of time. (Young, 'Nat. Phil.,' vol. i., p. 595.) This property of the pendulum was remarked by Galileo when a student at Pisa, by observing the vibrations of a lamp swinging from the roof of the cathedral, and was by him proposed as a medical instrument for observations on the pulse. (Drinkwater, 'Life of Galileo,' p. 5.) The simple pendulum was much used as an astronomical instrument (called *perpendiculum* in the older writers) before it was adapted by Huyghens to the clock. Mouton ('Observationes Diametrorum Solis et Lunæ,' Lugd., 1670) applied the vibrations of the simple pendulum successfully to measure the time in which the sun and moon describe their respective diameters, and in the Appendix, p. 427, proposes his *nova mensurarum geometricarum idea*, that is, a decimal system of measures based on the value of a minute in Riccioli's length of a degree. This is his *miliare*, the thousandth part of which he calls a *virga;* and the finds by experiment that the *virga*, which, according to Riccioli, is 5 ft. 4·363 in., Bolognese measure, is the length of a simple pendulum which makes 1252 oscillations in half an hour.

In 1671 Picart was sent to determine the position of Tycho Brahé's observatory at Uranibourg. He took this opportunity of swinging the pendulum, and found the length of the seconds pendulum 3 ft. 0 in. 8½ l. Paris measure, exactly the same as he had previously found it to be at Paris, and subsequently at Cette, on the south coast of France. Roemer obtained the same result at London, and these erroneous measures of Picart, the first astronomical observer of his day, were for a long time cited as objections to the theory of gravitation.

In 1672 Richer was sent to Cayenne (about 4° 56′ N. lat.) to make a course of observations, and among the rest to observe the length of the seconds pendulum. His words are: "L'une des plus considerables observations que j'ay faites, est celle de la longueur du pendule à secondes de temps, laquelle s'est trouvée plus courte en Caïenne qu'à Paris: car la mesme mesure qui avoit esté marquée en ce lieu-là sur une verge de fer, suivant la longueur qui s'estoit trouvée necessaire pour fair un pendule à secondes de temps, ayant esté apportée en France, et comparée avec celle de Paris, leur difference a esté trouvée d'une ligne et un quart, dont celle de Caïenne est moindre que celle de Paris, laquelle est de 3 pieds 8⅗ lignes. Cette observation a esté reiterée pendant dix mois entiers, où il ne s'est point passé de semaine qu'elle n'ait esté faite plusieurs fois avec beaucoup de soin. Les vibrations du pendule simple dont on se servoit, estoient fort petites et duroient fort sensibles jusques à cinquante-deux minutes de temps, et ont esté comparées à celles d'une horloge tres excellente, dont les vibrations marquoient les secondes de temps." ('Recueil des Observations faites en plusieurs Voyages par ordre de sa Majesté,*' p. 66, Paris, 1693.) We have cited this passage textually, not only on account of its importance, but because it is generally merely stated that Richer's clock, which was regulated on Paris time, lost more than two minutes at Cayenne. This misrepresents the *evidence* of the experiment, and moreover leaves room to suppose that Richer made a *chance* discovery, whereas the determination of the length of the pendulum was one of the special objects of his mission (see p. 2). Neither Picart nor Richer gives any details of his *modus operandi*.

In 1673 Huyghens published his 'Horologium Oscillatorium,' perhaps the most remarkable mathematico-mechanical work which preceded Newton's 'Principia.' He therein explains the *isochronism* of oscillations in a cycloid, and the mechanical means of making the pendulum swing in a cycloid. He gives theorems for finding the centre of oscillation of several figures, and thence the length of the simple pendulum, corresponding to a compound pendulum of certain forms; and in propositions 19 and 20 (p. 124–5) proves that when the body is the same, the distances of the axes of suspension from the centre of gravity are reciprocally as the distances of the centre of gravity from the respective centres of oscillation, and that the point of suspension and centre of oscillation are convertible. His proposition 25 (p. 151) is on the mode of fixing a universal and perpetual measure, which he proposes should be the third part of a seconds pendulum, and names a *horary foot*.

Newton, in his 'Principia,' lib. i., s. 10, investigates the oscillations of a body in a cycloid, or in any other curve; lib. ii., s. 6, he considers the effects of a resisting medium on a pendulous body; and lib. iii., prop. 19, he determines the figure of the earth, supposing it to be fluid and of uniform density, to be a spheroid of which the equatorial and polar diameters are as 220 : 229. In prop. 20 he computes the lengths of the seconds pendulum and of the degrees of the meridian, which are required on the foregoing suppositions; and he remarks, "Quod inequalitas diametrorum terræ facilius et certius per experimenta pendulorum deprehendi possit quam per arcus geographice mensuratos in meridiano." In the following pages is an analysis of the lengths of the pendulum which had come to his knowledge.

We have not been able to find any account by Graham himself of two very capital improvements which he seems to have introduced into pendulum experiments. The first is a clock, in which "he carefully contrived that its pendulum might at pleasure be reduced to the same length whenever there should be occasion to remove the clock from one place and set it up in another." (Bradley's 'Account of the going of a Clock by Graham, in London, and at Black River, Jamaica,' 'Phil. Trans.,' vol. xxxviii., p. 302.) Probably this was done by drawing the spring through a clip to a given mark; for in another description of a similar clock it is said the suspending spring was broken. We do not, however, see need for any adjustment in this respect, if the spring be pinned into the rod and into its upper axis. The pendulum was not compensated, but a thermometer was enclosed in the clock, and as the rate in different temperatures at the same place had been determined, the reduction to a normal temperature was easy. Clocks of this kind were supplied to the French expeditions for measuring arcs of the meridian in Lapland and Peru. For this latter expedition Graham supplied Godin with a *detached* pendulum, which Godin thus describes:—"Ce pendule est composé en general d'un fil de cuivre, d'une boule de même matière à un de ses bouts, et d'une pièce d'acier taillée en couteau à l'autre bout, qui est celui de suspension: ce couteau porte sur deux montants d'acier en deux points qui designent l'axe du

* This volume contains Picart's observations, as well as Richer's.

mouvement du pendule." ('Acad. Roy. des Sciences,' 1735, p. 507.) He says its motion was sensible for eighteen hours. It seems that this pendulum, the vibrations of which were to be counted by a clock, was also intended to measure the actual length of the pendulum. Messrs. Bouguer and La Condamine both had detached pendulums made after Graham's idea. Bouguer (same volume, p. 526) describes this pendulum as an invention of his own; La Condamine ('Journal du Voyage,' p. 143) is more open, and says he took the idea from a copy which Hugo made after Graham's. This is almost exactly Kater's invariable pendulum. Mairan's measurement of the length of the seconds pendulum ('Acad. Roy. des Sciences,' 1735, p. 153) is a good specimen of the old method of measuring the length of the pendulum: and the measures of Godin, Bouguer, and La Condamine, in the same volume, are worthy of notice. For references to various pendulum experiments, see Lalande, 'Astronomie,' 3rd edit., s. 2710, *et seq.*

In the first volume of the 'Transactions of the Society of Arts,' p. 238, Mr. Hatton proposed, as a mode of fixing a permanent standard of length, to suspend a weight from a fine hair to a clip in an upright bar, sliding up and down in a vertical frame. The hair passed through a fixed clip. The weight was to be swung, and the vibrations counted, in two positions of the bar, and from the difference in the times of vibration and the space through which the bar was moved, the length of the seconds pendulum was to be computed.

In 1787 Mr. John Whitehurst published 'An attempt towards obtaining invariable Measures of Length,' &c., which is remarkable for its ingenuity. He suspended a leaden ball with a flat steel wire in front of a straight upright frame, the wire being long enough to make forty-two oscillations in a minute. A clock with dead-beat escapement and a clip to hold the wire was slid up and down the frame, and secured and adjustable at two points where the clip made the free oscillations respectively forty-two and eighty-four in a minute. The crutch of the clock, being continued upwards in a screw, carried a weight, by moving which the oscillations of the crutch *alone* could be regulated to forty-two and eighty-four oscillations, and *therefore would not interfere with the free oscillation of the ball and wire, but only keep up their motion.* The going weight of the clock was in each case such as sustained an oscillation of 3°. It is clear that if all were properly executed, the clock-frame with its clip must have been shifted between the two positions through a space equal to the difference between the simple pendulums which correspond to forty-two and eighty-four oscillations per minute. A line was drawn in each position along the upper edge of the clock frame upon a brass rule fixed to the upright support, and this space was afterwards accurately measured, and the length of the simple seconds pendulum thence computed. Whitehurst's length of the seconds pendulum is 39·1196 inches of Troughton's standard, but the corrections for the buoyancy of the air and for temperature are not introduced. It is probable that he introduced greater errors than those he wished to get rid of in Hatton's method, for the real difficulty is not that of counting the vibrations, but of measuring the length between the two clips, in avoiding the errors of temperature, and the uncertainty as to the effective point of suspension. The *principle* of Hatton's method, that of measuring the difference between two pendulums, has been adopted, as we shall see, by Bessel.

The foregoing account is merely a sketch of the history of this mechanical problem, which in the hands of Borda, and more recently of Kater and Bessel, has received a more accurate solution. There are still anomalies and imperfections in some parts of the processes which require clearing up, but the errors have been reduced within comparatively moderate limits. Before describing these experiments we shall give a brief account of the formulæ which they require.

The expression which connects the time of one oscillation of a simple pendulum in an infinitesmal arc, with its length l, at a place where the force of gravity is represented by g, is $t = \pi \frac{l^{\frac{1}{2}}}{g^{\frac{1}{2}}}$, π being 3·141596, or circumference to diameter 1; the measure of gravity g, being twice the space through which a body would fall freely in 1^s, or, what is the same thing, the space through which a body would move in 1^s, with the velocity which it acquires in falling freely for 1^s.

Hence if l be the length of the simple seconds pendulum, $g=\pi^2 l$; therefore g is known when l can be measured. The process therefore of finding the effective force of gravity at any place is reduced to finding the length of the simple pendulum which vibrates seconds.

The French astronomers, in their great survey of the arc of the meridian, determined the *absolute* length of the pendulum at different stations between Dunkerque and Formentera, and also in the continuation to Unst in the Shetland Isles, which is included in the English trigonometrical survey. It is, however, an operation of great delicacy, and when only the *variation* of gravity between different places is required, as is the case in researches into the figure of the earth, the observation may be more easily performed by swinging the *same* pendulum in different places, and ascertaining the number of vibrations which it makes in a day. Thus if n and n' be the number of vibrations made in a day by the *same* pendulum l, at two different places at which the forces of gravity are g and g', and the duration of one vibration at each place be t and t', then since the time of one vibration = a day divided by the number of vibrations, we shall have—

$$\frac{1}{n} : \frac{1}{n'} :: t : t' :: \pi\left(\frac{l}{g}\right)^{\frac{1}{2}} : \pi\left(\frac{l}{g'}\right)^{\frac{1}{2}} :: \frac{1}{g^{\frac{1}{2}}} : \frac{1}{g'^{\frac{1}{2}}},$$

$$\text{or } g : g' :: n^2 : n'^2.$$

That is, the force of gravity varies as the square of the number of vibrations of a given pendulum in the same time, which is usually taken to be a mean solar day. If, therefore, the number of vibrations of a pendulum in one day at a given place, London for instance, be known, and it is then transported to different places, and the number of vibrations in a day counted, a simple proportion will connect the forces of gravity at London and every place at which the observation has been made.

If the length l' of the simple pendulum at any station be required from these observations,

$$\text{since } l : l' :: g : g' :: n^2 : n'^2,$$

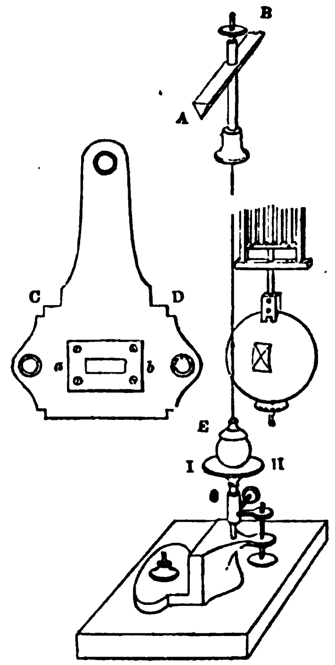
$l' = \frac{l\,n'^2}{n^2}$, which gives the length of the pendulum at any place in terms of the length at London, and the number of vibrations per diem at that place and London.

Though it scarcely belongs to our subject, we will give the expression by which the ellipticity of the earth is determined from pendulum observations. The length of the seconds pendulum at any latitude, λ, may be supposed $l = \text{A} + \text{B}\,.\,\sin.^2\lambda$, where A and B are constant quantities. Now from all the good observations, either of the actual length or the number of vibrations per day of the same pendulum, determine the values of A and B; then, by Clairaut's theorem,

$$\text{the ellipticity of the earth} = {}^{*}\cdot 008668 - \frac{\text{B}}{\text{A}};$$

whence the ellipticity is found. By ellipticity is meant the excess of the equatorial over the polar radius of the earth, divided by the polar radius.

The apparatus of Borda will be generally intelligible from the following description and figures.



Borda's Pendulum Apparatus.

The plumb-line is suspended from a knife-edge piece, A B, and is attached below to a cup, E, which is ground to fit very exactly the platinum ball below. A little grease is rubbed on the inside of the cup, making the contact perfect enough to exclude the air and to suspend the ball. The knife-edge rests on agate planes, a, b, which are carefully levelled, and the frame C D, which carries the planes, is fixed immoveably in a horizontal position. The plumb-line is in front of the comparing clock, which has a small cross drawn on the bob. When both

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[*] This is Mr. Airy's value for $\frac{5m}{2}$ where m is the ratio of the centrifugal force at the equator to the force of gravity there. ('Encyclopædia Metropolitana,' Figure of the Earth, sect. 2.) Biot, 'Astronomie,' vol. 3, additions, p. 169, gives 0·00865; the centrifugal force m being supposed $\frac{1}{289}$ of the force of gravity at the equator.

are at rest, a telescope having a vertical line in the focus is placed a few feet distant, so that the cross, the plumb-line, and the fixed wire of the telescope are all in the same right line, and all seen *distinctly.** Such a length is given to the plumb-line as that its oscillations shall be a little slower than those of the clock.

The clock is now set a-going, and when it is quite steady, the platinum ball is drawn a little on one side, and made to swing through a very small arc, one or two degrees at the most. The observer then places himself at the telescope, and notes the exact beat of the clock when the plumb-line bisects the cross and coincides with the fixed wire at the same time: this is called a *coincidence*. As this observation seems much less definite than in Kater's method, it is better to note those beats before and after the coincidence, when the eye cannot distinguish whether it is a coincidence or not, and to take the mean of the two for the true time of coincidence. Immediately after, the extent of the arc through which the plumb-line swings is to be read off on a scale placed just behind it; the thermometers which are near the pendulum must also be read off, and also the height of the barometer. The observer now waits until this appearance presents itself a second time (which may be in about ten minutes, though the interval is quite *ad libitum*), and having thus established the time which elapses between the observations, he may leave the apparatus for three, four, or five hours, when on his return the same observations must be repeated of coincidence, arc, temperature, and barometer, and the series is finished. We should recommend closing as well as commencing a series with two coincidences *in majorem cautelam*, but except as a check, no observations are required except the first and the last. The plumb-line is again set in motion exactly as before, and the second, third, and following series observed. The rate of the clock is established by astronomical observation.

After a satisfactory number of series has been taken, the next object is to measure the length of the pendulum. The plane I H is raised by a fine screw until it just touches the bottom of the platinum ball. This is an operation of great nicety, and must be effected by two or three trials, as the *exact* temperature of the wire at the *exact* moment of contact is required; and the presence of the observer, even for a short time, is sufficient to affect a slight wire very sensibly. Suppose this done, the apparatus is removed or pushed on one side, and a bar, which has a knife-edge above and a sliding tongue below, is suspended in its place. The tongue is slid down until it touches the plane I H, and the distance between the knife-edge and the bottom of the tongue measures the distance between the top and bottom of the pendulum. This distance may be measured in several ways; the French astronomers use a contrivance which need not be described here.

One of the great practical difficulties in this species of pendulum experiments seems to be the extreme and sudden sensibility of the plumb-line to temperature. The whole apparatus is enclosed in a glass cage to exclude currents of air, and the observer is particularly careful, after bringing the lower plane into contact with the bottom of the ball, to absent himself until the temperature is steady, and then to make the contact complete. It is another objection that the different manipulations required are of great delicacy, and therefore not suited to every observer and every place; but when the utmost care and skill are employed, the results appear satisfactory.

The knife-edge, A B, by which the line and ball are suspended, is an ingenious contrivance, exactly similar to Whitehurst's synchronous crutch above described. By the upper screw and weight, the oscillations of the knife-edge *alone* can be made synchronous with the oscillations of the whole pendulum, so that the oscillations are just the same as if the knife-edge were immaterial, and the point of suspension exactly in the line of its edge. The platinum ball can be suspended from any side, and if two positions diametrically opposite be taken, the effect of any irregularity of shape or density disappears from the mean of the two results. There are several corrections to be applied to the quantities immediately given by observation, before the length of the simple pendulum can be concluded. The oscillations are made in an arc of sensible extent. Now the time of oscillation in an arc of A° on each side the lowest point, is greater than the time in an infinitely small arc (which is the arc required), in the proportion of $1+\frac{\sin.^2 A^\circ}{16}$ to 1. An expression which depends upon the first and last arcs of each series, gives the correction which is to be added to the number of oscillations observed. This is taken from a table. Between each coincidence, the plumb-line has made two oscillations less than the clock, therefore subtracting twice the number of coincidences from the number of seconds elapsed between the first and last coincidences, you will have the number of oscillations of the pendulum during a certain time shown by the clock. Each of these numbers requires a correction: to the number of oscillations of the pendulum, must be added the correction for arc just mentioned; and to the time as shown by the clock, the proportional part of its rate during the experiment. A simple proportion will now give the number of infinitely small vibrations in 24 hours.

Further corrections are to be applied. The length of the wire and ball during the observations must be reduced to the length they would have had at the temperature when the contact with the plane and the measurement was made, and this again must be converted into the equivalent length when the thermometer is at the freezing-point, which is the French standard temperature. The theoretical pendulum is supposed to swing *in vacuo*, and as the density of the air affects the time of oscillation two ways, both by diminishing the moving force of the pendulum and by adding * to its inertia by the air carried along with it, a correction is required on this account, which depends upon the barometer and thermometer, on the specific gravity of the materials of the pendulum, and also on its form.

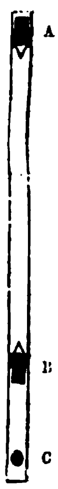
From the dimensions and specific gravities of the parts of the apparatus, the distance between the centre of oscillation and the bottom of the ball can be computed. Hence the length of the simple pendulum, which oscillates in an infinitely small arc a certain number of times in a day and *in vacuo*, can be assigned, from which the length of the seconds pendulum is deduced by simple proportion.

If the place of observation be above the level of the sea, it is usual to reduce the length to what it would have been at the sea-level. This is a very uncertain quantity, as it depends upon the configuration and density of the strata in and near the spot. In the earlier experiments gravity was supposed to vary inversely as the square of the distance from the centre of the earth, and thus the attraction of the matter between the observer and the sea-level was wholly neglected. Dr. Young showed that in a table-land of average density the correction thus obtained was too large, and should be multiplied by 0·66.

For a full description of Borda's method, with instances, &c., see 'Base du Système Métrique Décimal,' vol. iii., p. 337 (Borda's original memoir); and again, vol. iv., p. 441 ('Observations from Formentera to Unst').

Many modifications and improvements have been introduced into Captain Kater's method of determining the length of the pendulum, and we must refer to his paper ('Phil. Trans.,' 1818, p. 33) for a minute description and for a plate of his apparatus.

The principle of his method is founded on the beautiful dynamical theorem due to Huyghens, which we have already mentioned, namely, that the axis of suspension and centre of oscillation are reciprocal in the same body. Now conceive two wedge-formed pieces of steel (knife-edges), with the sharp edges towards each other and parallel, to be fixed at right angles to a bar of any form whatsoever, and in a line passing through its centre of gravity; then if the time of oscillation on either edge be the same, the distance between the knife-edges is the length of the simple pendulum which swings in the same time. Captain Kater, in his experiments, used a pendulum of an inconvenient form, the same nearly as in his invariable pendulum (see cut of Kater's invariable pendulum), with a second knife-edge below the centre of the bob, and there are several doubtful points in the reductions which he employed and the subsequent measurement between the edges; still his memoir must always be carefully perused by any future experimenter who wishes to make himself thoroughly acquainted with the subject. The method of observing the coincidences is remarkably ingenious and accurate.



Baily's Convertible Pendulum.

We conceive that the best form of pendulum for the object of measuring the actual length according to Kater's method is that adopted by Mr. Baily. A C is a rectangular bar, with one knife-edge at the end A, and the other at B, about ⅔ of the length from the same point. A should be as near the end as sound workmanship will allow. The necessary verifications, namely, the parallelism of the knife-edges, their perpendicularity to the bar, and that the line which joins the knife-edges passes also through the centre of gravity, are all very simple, and there is little difficulty in adjusting the oscillations on each knife-edge to synchronism.† This bar pendulum is suspended on agate planes in front of the clock, great care being taken that the support is perfectly firm and the agate planes horizontal. A white disc of a spindle shape and exactly the width of the bar is pasted on the clock bob, and the viewing telescope fixed in a line with the disc and bar, so that, both being at rest, the white disc is just covered by the bar. Captain Kater used a diaphragm in his telescope, the sides of which were parallel to the bar and touched its edges; but it has been found more convenient to place a pair of parallel plates between the bar and the disc, the sides of which are so adjusted as just to allow the disc on the clock bob to be seen between them. There is a divided scale to mark the arc of vibration, two or three thermometers are hung at different heights about the pendulum bar to register the temperature, and there is a barometer for the atmospheric pressure, all which are to be read at the beginning and end of each series. The observation itself is of the simplest kind.

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* This is not always practicable, and it would, generally speaking, be better to place a lens between the cross on the clock-bob and the plumb-line, and to form an image of the cross upon the plumb-line. It is desirable on many accounts that the two pendulums should not be very near each other.

* This part of the correction due to the air was omitted in the French experiments and in Captain Kater's: see Mr. Baily's memoir referred to above, and AIR.

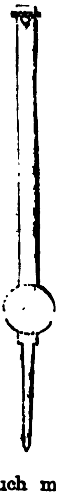
† This may be done two ways. Place the knife edges A and B at the distance which will give the proper interval for coincidences, 39·4 inches for instance, A being at one end, and make the bar rather more than one-third longer; then the oscillations on B will be slower than those on A. By filing

Set the clock going, and when its arc is steady, give the pendulum a small motion, 1° or 1½° at the utmost. The white disc, which is at first wholly visible, is gradually invaded by the bar, till at last it is entirely covered, first one side and then the other disappearing.* These times of *disappearance* are to be noted. Almost immediately after, the white edges reappear, first on one side and then on the other, and these *reappearances* are noted. The mean of the four gives the true time of coincidence. It has been found convenient in practice not to make the adjustments with the highest degree of precision, for you are then in doubt on which side the first disappearance and reappearance will take place; whereas if there is a very little displacement, attention need only be fixed on every alternate beat, which is less strain on the eye and on the mind. This displacement however must be trifling, otherwise, when the arc becomes small, the disappearances and reappearances will not take place. The reductions for the rate of the clock, for the arc of vibration, the temperature, the buoyancy of the air and its inertia, and the height of the place of observation above the sea-level, are all to be made as in Borda's pendulum. For the details we refer to the standard memoirs which have been published on the subject. But there are two or three points which deserve more attention than they have generally met with. The clock is only to be considered as a counter of the vibrations, and to avoid any error arising from its irregular rate, the observations should be continued without intermission between two epochs, at each of which the error of the clock is ascertained by astronomical observation. If this be done, the only reliance upon the clock is for the short time which elapses between the last coincidence of one series and first of the next. It is true that this mode of observing requires artificial illumination, for it must be continued day and night. This is no disadvantage, but the contrary, for as the other great practical difficulty is that of ascertaining the exact temperature and keeping it steady, the best place for observation is a deep roomy vault or cellar.

The correction for the buoyancy of the air depends on the *specific gravity* of the pendulum; that arising from the dragged air, which we have called inertia, on its *form*. It is very desirable that the experiments should be made *in vacuo*, and where that is difficult or impossible, as in a travelling apparatus, the law and quantity of the correction for each pendulum should have been previously experimentally determined *in vacuo*. The variation for temperature should be got from a comparison of summer and winter experiments at the same place. In addition to the height of the place of observation above the sea-level, a rough survey should be taken of the form of the surrounding country, and of the kind of strata, with the specific gravity of each. This is particularly necessary where the heights are considerable. (See Young's Remarks, 'Phil. Trans.,' 1819, p. 93.)

Still, when every known precaution has been taken, there are anomalies in the results of this experiment which are not yet clearly understood. It is very difficult to make the edge of the knife perfectly straight, and to keep it so when it is fastened to the bar. There is considerable uncertainty in measures of distance between the reciprocal knife-edges; and lastly there is no authorised standard of length at present existing in England in terms of which the distance can be expressed. The length of the simple pendulum which vibrates seconds in the latitude of London, is not at present known with the degree of certainty† which the importance of the problem demands, and which is attainable.

Captain Kater proposed the following form of pendulum for determining the number of oscillations which the same pendulum describes in different places, which is nearly the same as Graham's, above described. Mr. Baily prefers the bar with two knife-edges, the same as that used for determining the absolute length, and he directs observations to be made at each place with both knife-edges. There is certainly a great advantage in having a check upon the knife-edges, as a discrepancy between the two results (supposing the pendulum to have been previously regulated) will show that one of the knife-edges has been injured. To ascertain which of the two it is, requires a second pendulum. Upon the whole, though we prefer Mr. Baily's pendulum to Captain Kater's, yet we think a form suggested by Mr. Airy is, for ordinary purposes, still better—it is, to have the knife-edge placed in that part of the bar where the oscillations take place in the shortest time. In this case it seems probable that any ordinary injury of the knife-edge will not alter the time of vibration. The observer must be very careful in these stiff bars to see that the pendulum is truly vertical, a precaution which in Kater's flexible bar is less necessary. If an observer chooses to have a second knife-edge opposite the former in the pendulum of minimum vibration, there is no objection except the increased resistance of the air, the increased correction for inertia, and the chance of confounding the two positions. The mere observation of the coincidences, which in its present form was first introduced by Kater, is so simple that it will be successfully performed by any person the first time of attempting it, and an error of a second or two in noting the moment is a matter of little importance. There is a far greater latitude for error in noting the temperature and ascertaining the clock-rate, but there is another anomaly attending the knife-edge pendulums, only partially understood at present, which is much more vexatious than temperature or clock-rate. As the pendulum swings about those points of the knife-edge which are in contact with the agate planes, it is clear that, supposing any imperfection in both, these points may be altered, when the axis of suspension, and consequently the time of oscillation, will be altered too. Hence it is advisable to place the knife-edge as exactly as possible always in the same position on the agate plane, both as to front and back, and also as to right and left. It will generally be found that turning the pendulum half round on the same knife-edge will alter its time of vibration sensibly, so that the face in front must always be registered. But even when these precautions are taken, anomalies are still found, which we can only attribute to the following cause:—In most of the pendulums hitherto made the steel knife-edge has been fixed upon a bar of different metal (brass and copper) with stout brass knees, and the two screws which fix the steel knife-edge to the brass knees are at some distance from each other. Now if, from the difference of expansion between the brass knees and the knife-edge, the latter should be curved, not upwards or downwards, but in a horizontal plane, the consequent alteration of time in the oscillation may be very considerable. The steel edge therefore should either be controlled by being ground on a narrow slip let into a brass wedge, or the attaching knees should also be of steel. The uncertainty which appears due to some such cause as that above described may amount to one, two, or even more seconds a day in the invariable pendulum, either of Kater's or Baily's construction. It is evident that in measuring the actual length of the pendulum this error may be further increased, for the problem assumes the perfect parallelism and truth of a pair of knife-edges. For an account of knife-edge bar pendulums, see Kater's *Convertible* Pendulum, with Young's Appendix, 'Phil. Trans.,' 1818, p. 33; Kater's *Invariable* Pendulum, 'Phil. Trans.,' 1819, p. 337; Sabine's Experiments to determine the Figure of the Earth, London, 1825; Sabine's Comparison of the Length of Pendulum at London and Greenwich, 'Phil. Trans.,' 1829, p. 83; Sabine, On the Reduction to a Vacuum, 'Phil. Trans.,' 1829, p. 207; Baily, On the Reduction to a Vacuum, 'Phil. Trans.,' 1832, p. 399; Foster's Pendulum Experiments, edited by Mr. Baily, 'Mem. Ast. Soc.,' vol. vii. (at page 96 is given a table of the results of the most accurate modern pendulum experiments). See also WEIGHTS AND MEASURES.



Kater's Invariable Pendulum.

The last important measurement of the length of the pendulum, which is undoubtedly the most satisfactory, is due to Bessel, and is described by him in his 'Untersuchungen über die Länge des einfachen Secundenpendels,' Berlin, 1828, which forms part of the 'Transactions of the Academy of Berlin.' The principle of his measure is the same as Hatton's. Bessel procured from Paris a verified copy of the toise of Peru; this he placed upright, and suspended his ball and wire first from the top and then from the bottom of the toise, the ball being in both cases at the same point below: the time of oscillation in each position was compared with a clock in front. From the difference of the times of oscillation of these two pendulums, and the difference in their length, which is a toise, the length of the seconds pendulum was computed in parts of the toise. Bessel suspended his pendulum by passing a flat and very slender spring over a small cylinder, the spring being continued downwards to the ball in a fine wire. We must refer to the original memoir for a description of the different elaborate contrivances which were introduced by Bessel and Repsold for securing accuracy in every part of the process. All conceivable causes of error are considered, and the effects have been computed and allowed for. The final result is that the length of the seconds pendulum at the sea-level in the latitude of Königsberg, 54° 43′ N., is 440·8179 lines of the toise of Peru; this we consider to be a measurement of the actual

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from the end c, these may be made to agree after two or three trials, or if the pendulum should be too short, a weight may be added at this end, such as is pointed out by the black dot near c.

* Mr. Baily uses two slips of gold leaf pasted on a tail to his clock pendulum for a disc, which answers very well. In the experiments at Dolcoath mine, Messrs. Airy and Whewell had a disc of enamel at the end of a small rod, which was screwed into the bob and projected from it. The disc could be inclined so as to appear of the proper breadth and to receive an oblique illumination. This part of the experiment is almost irreproachable, but perhaps in future it would be safer to place the clock and pendulum at greater distances from each other, and to get sharp edges by interposing a lens.

† Captain Kater's measure was doubtful in several respects, and though it has been partially corrected, it is still uncertain. He expressed the length of the pendulum in terms of Sir George Shuckburgh's scale (which has probably suffered injury since that time), and this he found to be identical with the parliamentary measure declared to be standard by the 5 Geo. IV., c. 74. The Act of Parliament standard was destroyed when the houses of parliament were burned. Fortunately a very beautiful scale of 5 feet had been previously made for the Astronomical Society, and three feet in this scale had been compared many hundred times with the parliamentary standard. As almost all the recent scales and comparisons which have been made in England have been compared with this last-mentioned scale, it must be considered to be the scientific English standard, and the best evidence of the parliamentary standard which exists. The definition for restoring the yard, if lost, according to the Act of Parliament, that is, by the length of the seconds pendulum, as it depends upon an erroneous determination, would give a new standard, differing sensibly from the previous one which it was meant to preserve. (Baily's Report on a Standard Scale, 'Astron. Soc. Mem.,' vol. ix. p. 35.)

length of the pendulum, and perhaps the only one, which is deserving of full confidence.

We have already pointed out the manner in which experiments with the pendulum are used to determine the figure of the earth, and stated that for this purpose the simple bar with a knife-edge at the point of minimum oscillation seems the most fit. If the present imperfections can be overcome, which we see no reason to despair of, there is another research, that of the mean density of the earth, for which such an instrument is peculiarly adapted. The density which has been hitherto acquiesced in, depends on the attraction of Schehallien upon a plumb-line, observed by Maskelyne, and upon the attraction of leaden balls measured by a torsion balance, according to Cavendish, and more recently by Reich. Now in the Schehallien experiment the whole deflection caused by the mountain was only 11″·2, which, under the circumstances, might very easily be 2″ or even 3″ wrong either way. The Cavendish experiment has been repeated in this country by Mr. Baily, who from upwards of 2000 experiments has arrived at the result 5·67 as the density of our globe. Still however it was desirable to adopt other modes of experiment, which we now proceed to point out.

If an invariable pendulum can be made which is only affected by known causes of which the effects can be calculated, the simplicity and perfection of the observation by coincidences, and the unlimited time for which it can be carried on, will supply a much broader and more secure base for the solution of this important problem, and one more readily and universally applicable. Two attempts were made by Messrs. Airy and Whewell, first by themselves, in 1826, and afterwards, in 1828, with the assistance of three Cambridge friends, to deduce the mean density of the earth from observing the oscillations of detached pendulums at the top and bottom of Dolcoath Mine, one of the deepest in Cornwall. As the first operation was less carefully planned, we shall confine our account to the second, which was altogether the best arranged pendulum experiment which had come to our knowledge up to that time, and only failed from a cause then first discovered, namely, that invariable pendulums of Kater's construction are very uncertain and inaccurate instruments. We will call the two pendulums 1 and 2. These were placed on their stands opposite each other, and put into motion at the same arc (a board being interposed to prevent their reciprocal action through pulses of the air), and the times of coincidence observed. A few series were thus made, in which the errors of observation scarcely amounted to a hundredth of a second per day.* Pendulum 1 was then sent to the bottom of the mine, and and set up with its clock and proper accompaniments. Pendulum 2 was established with its clock in a hut at the surface. We will call the observers A, B, C, D, E. A set off at six in the morning, commenced a series with pendulum 2, and compared eight pocket chronometers with the clock by coincident beats through a sidereal half-seconds chronometer.† He then descended the mine and commenced a series, compared his chronometers below exactly as he had done above, and then sent them back to the upper station. By this time E had arrived at the upper station to finish the series which A had begun, and to compare the chronometers on their return. In this way the clocks were compared, without a possible error of $\frac{1}{20}$th of a second. After finishing his first series and commencing a second, A returned to day (in the miner's language, to *grass* ‡). This series was completed by B, who set off at 2 P.M., made a third shorter series, and commenced a fourth. The night-work was taken by C or D, one of whom descended at 10 P.M., finished B's series, and commenced a fresh one; on his return to day he finished the upper series which E commenced before going to bed, and started another, which was finished by A before his next descent. In this way observations were continued from Monday morning, July 11, to Saturday afternoon (127 hours). On comparing the results of each day, it was found that the three first days agreed extremely well, showing an acceleration of about 2^s per day in the lower pendulum; but the two next days, this acceleration was about double. The only mode of accounting for this unexpected and very unwelcome result was, that the knife-edges and agate planes were imperfect, and that the time of oscillation depended on the position of the pendulum on its plane. This had never been suspected before; for confidence in the accuracy of the pendulum was at that time almost an article of faith among experimentalists. To ascertain this, a second series of comparisons was made between pendulum 1 and 2, taking care to place the knife-edges exactly in the same position on their planes, and that the faces were turned the same way. These comparisons were necessarily hurried, as a slip had taken place in the mine near the engine-shaft, which deranged the action of the pumps, and forced the experimenters to repeat their operations below without delay. Pendulum 1 was again sent below, and the experiment repeated exactly as described above, for three days (79 hours), until the underground observers were driven out by the water. Notwithstanding all the precautions which had been taken,* the observations of the last day gave a different result from the two first. "The conclusion therefore on which the experimenters were unavoidably forced was, that even with the care and attention they had used, the pendulum could not be trusted." The pendulums were a third time compared with each other above ground, and the intervals of coincidence were found to vary, without any assignable cause, from $20^m\ 24^s$ to $20^m\ 17^s$, and back again from $20^m\ 20^s$ to $20^m\ 29^s$; and finally, *during one series of oscillations, without being touched, or any one entering the room*, the time of coincidence changed from $20^m\ 25^s$ to $20^m\ 18^s$, and at last to $20^m\ 3^s$. It was therefore clear that while the mode of observing was perhaps sufficient to detect a difference of a hundredth of a second a day (except from the effects of temperature, which might amount to a tenth of a second), the pendulums themselves, though used with the utmost skill and precaution, and *under the same circumstances*, were liable to errors of two seconds or more per day.

In 1854 Mr. Airy repeated this experiment under more favourable circumstances on the banks of the Tyne, and at the bottom of a pit of Harton colliery, one of the deepest coal-pits in this country (1260 feet below the surface). Advantage was taken of electro-telegraphy to make the comparisons between the upper and lower pendulums, which were found to differ in rate 2¼ seconds per day, from which it followed that the gravity for that depth was increased by the $\frac{1}{19190}$th part. The density of the earth as deduced from this result is between six and seven times that of water, but Mr. Airy imagines that he has not taken full account of the hollow of the Tyne, of the basin named Jarrow-slake, of the scoop indicated by the sea, and of the real and observed specific gravity of the rocks which cover the mines of Harton. Further details on this subject will be found under EARTH, MEAN DENSITY OF THE. [See also GYROSCOPE.]

PENETRABILITY. Under IMPENETRABILITY are given a few examples of the apparent penetration of one body by another; and, indeed, examples of this kind are more apparent than real. There are many instances in chemistry in which a body is dissolved in water, or other liquids, without visible increase in bulk. A measure of sulphuric acid mixed with one of water, will give less than the sum of the two; but it is not supposed that in such cases there is any penetration of matter, but only an alteration in density, and in the relation of the compound to heat, &c.

PENITENTIARIES. [PRISONS.]

PENITENTS. [PENANCE.]

PENNY. [COIN; MONEY.]

PENSION, an annual sum granted by the state to an individual. The grounds upon which pensions are granted by the state differ according to the nature of the government. In a monarchy the services rendered to the sovereign by those who surround his person will recommend them as fitting objects of reward: where a mixed form of government prevails, attempts will be made to establish some standard of reward independent of personal bias or caprice. In this country the distribution of pensions is now almost entirely subject to the control of the legislature; but the following notice will show that persevering and long continued-efforts have been necessary to place it upon this footing.

Before the reign of queen Anne, the kings of England alienated or encumbered their hereditary possessions at pleasure, and the courts of law sustained them in the exercise of this power. In 1690-91, Chief-Justice Treby, in answer to the objection that such power might lead to the destruction of the revenue, said, "This might be some reason to induce the making of an act of parliament to restrain the king's power of alienation; but since here the parliament has thought fit to give the king such a power, we ought to acquiesce and submit to it." ('State Trials,' vol. xiv., p. 30.) By the 1 Anne, c. 7, the right of burdening the revenue of the crown with improvident grants, to the injury of the successors of the throne, was materially abridged. This statute, after reciting that "the necessary expenses of supporting the crown, or the greatest part of them, were formerly defrayed by a land revenue, which had from time to time been impaired and diminished by the grants of former kings and queens of this realm," enacts that no grant of manors, lands, &c., shall be made by the crown from and after the 25th of March, 1702, beyond the term of thirty-one years or for three lives, reserving a reasonable rent. As this clause applied only to the land revenue, it was enacted by another clause that no portion of other branches of revenue, as the excise, post-office, &c., should be alienable by the crown beyond the life of the reigning king. On the accession of George III., in consideration of the surrender of the larger branches of the hereditary revenue, a civil list was settled on his majesty, amounting originally to 800,000*l.*, and afterwards increased to 900,000*l.*, on which the pensions were charged. There were no limits, except the Civil List itself, within which the grant of pensions was confined; and at various times, when debts on this list had accumulated, parliament voted considerable sums (Sir Henry Parnell, in his work on 'Financial Reform,' says "some millions") for their discharge. In February, 1780, during the administration of Lord North, Mr. Burke introduced his bill for the better security of the independence of parliament and the economical reformation of the civil and other establishments. In this bill it was recited that the pension lists were excessive, and that a custom prevailed of granting pensions on a private list during his majesty's pleasure, under colour that in some cases it may not be expedient to divulge the names of persons on the said lists, by means of which much secret and dangerous corruption may be hereafter practised. Mr. Burke proposed to reduce the English pension list to a maximum of 60,000*l.*, but the bill, as passed, fixed it at 95,000*l.* This act (22 Geo. III., c. 82) asserted the principle that distress or desert ought to be considered as regulating the future grants of such pensions, and that parliament had a full right to be informed in respect to this exercise of the prerogative, in order to ensure and enforce the responsibility of the ministers of the crown. Mr. Burke's speech on introducing his bill will be found in the third volume of his 'Works,' ed. 1815.

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* In a series of six hours, the first and last coincidences could be so observed as not to admit an error of more than 2^s for the whole interval, and the coincidences followed each other in about twenty minutes. A bright strip was rubbed off each edge of the tail of the farther and quicker pendulum, and this was illuminated by a lamp placed obliquely. The corrections for arc, barometer, temperature, were the same for each. The time was taken from an excellent chronometer.

† The comparison of a single chronometer was scarcely ever in error $\frac{1}{10}$th of a second, generally within $\frac{1}{50}$th. The ½ seconds sidereal chronometer was compared first and last with the pendulum clock, going nearly solar time, and in the interval three or five coincidences of each pocket chronometer (which beat $0^s{\cdot}4$ solar time) were observed with the sidereal chronometer.

‡ A miner divides the visible world into two parts, *underground* and *at grass*.

* A considerable difference was found in the temperature of the upper and lower part of the hut during the first upper ground experiment, from the heat of the lamp for illuminating the disc, which was kept continually burning. Before the second experiment, a side lobby was boarded off, in which the observer placed the illuminating lamp a minute or two before the coincidence took place. The lamp-light was thrown by a reflector on the disc through a hole in the boarding; and when the coincidence had been observed, the lamp was withdrawn and the hole stopped with flannel. The clock-face was illuminated for a short time before coincidence by a lamp with a powerful reflector through a hole in the front partition, which was also withdrawn and the hole stopped when the observer had caught the number of the beat. With these precautions, the temperature was perfectly steady, and sensibly the same at all altitudes and throughout the twenty-four hours.

Up to this time the Civil List pensions of Ireland, the pensions charged on the hereditary revenues of Scotland, and the pensions charged on the 4½ per cent. duties, had not been regulated by parliament.

In Ireland the hereditary revenue of the crown was used as a means of extensive political corruption, the English act of 1 Anne, already cited, not being applicable to Ireland. In a speech of Mr. Hutchinson, secretary of state, made in the Irish House of Commons, in June, 1793, he stated that the gross annual hereditary revenue of Ireland amounted to 764,627*l.*, reduced by various charges to 275,102*l.* only; that the disposition of this revenue was in the hands of the king; that "his letters and seals were the only authority for using it, and the only voucher allowed by the Commissioners of Accounts and by the House of Commons;" and that there was no Board of Treasury executing their functions under the authority of parliament. The Irish parliament, in 1757, had come to a unanimous resolution, "That the granting of so much of the public revenue in pensions is an improvident disposition of the revenue, an injury to the crown, and detrimental to the people." The Irish pensions then amounted to 40,000*l.*: in two years after the above resolution was passed, an addition of 26,000*l.* was made to them; and in 1778 they were nearly double the amount at which they stood in 1757. In 1787 leave was refused to bring in a bill to limit the amount of pensions, and to disable persons holding pensions for a term of years, or during pleasure, from sitting and voting in parliament. Mr. Forbes, who moved this bill, stated that "it was a practice among certain members of the House to whom pensions had been granted, to carry them into the market and expose them for sale." In 1790 Mr. Forbes again moved resolutions, stating "that the Pension List amounted to 101,000*l.*, exclusive of military pensions; that the increase of pensions, civil and military, since February, 1784, had been 29,000*l.*; and that many of these pensions had been granted to members of parliament during the pleasure of the crown." These resolutions were not adopted. In 1793, when the whole policy of the Irish government was changed, among other beneficial measures introduced and recommended on the authority of the lord-lieutenant was a bill to limit the amount of pensions and to increase the responsibility of the Treasury, which was passed into a law. By this act (33 Geo. III., c. 34, Irish statutes) the pensions on the Civil List in Ireland were limited to 80,000*l.*, allowing a sum of 1200*l.* only to be granted until such reduction was effected. Grants held during the pleasure of the crown, and converted into grants for life to the same parties and to the same amount, were exempted from the limitations of the act. This act carried into effect a surrender of the hereditary revenues for the life of the king, and the principle of appropriating money by parliamentary authority. These restraints on the crown were not however equal in efficiency to those contained in the English statute of Anne. At the time of the act of 33 Geo. III. being passed, the Irish pensions amounted to 124,000*l.*, and the amount was not reduced to 80,000*l.* until 1814. By the 1 Geo. IV., c. 1, the Irish Pension List was further reduced to 50,000*l.*, no grants exceeding 1200*l.* to be made in any one year until the list was so reduced.

The statute of 1 Anne, having been passed prior to the Union, did not affect Scotland; and pensions were accordingly granted by the crown for life or for lives, in possession or in reversion, without restriction in amount or in the duration of the grant, other than the amount of the revenues and the claims and burdens already upon them. By the 50 Geo. III., c. 3, the principle of parliamentary interference was established in reference to the hereditary revenues of Scotland, the amount of the pensions was reduced to 25,000*l.*, and no more than 800*l.* was to be granted in any one year until such reduction was effected. At this period the Civil List pensions of Scotland amounted to 39,379*l.* By the 1 Geo. IV., c. 1, the hereditary revenues of Scotland were placed to the account of the consolidated fund.

Certain duties, called the 4½ per cent. duties, were not withdrawn from the private control of the crown until 1830, when they were surrendered by William IV. for his life, the pensions then chargeable upon them continuing payable. On the acession of William IV. there was nothing therefore to prevent the Pension Lists of England, Ireland, and Scotland being consolidated; and this was effected by 1 Will. IV., c. 25, which also made provision for their reduction, on the expiration of existing interests, from an amount of 145,750*l.* net, to a future maximum sum of 75,000*l.* The Pension List for England was at this period 74,200*l.* net; Scotland 23,650*l.*; Ireland, 47,900*l.*

In 1830 the ministry of the Duke of Wellington was overthrown on the question of referring the Civil List (which comprises the Pension List) to a select committee, Sir Henry Parnell's motion to that effect being carried by 233 against 204.

In February, 1834, in order to define with greater precision the class of persons to whom the grant of pensions ought to be confined, Lord Althorp, chancellor of the exchequer (afterwards Earl Spencer), moved resolutions to the following effect, which were agreed to by the House of Commons:—"That it is the bounden duty of the responsible advisers of the crown to recommend to his majesty for grants of pensions on the Civil List such persons only as have just claims on the royal beneficence, or who, by their personal services to the crown, by the performance of duties to the public, or by their useful discoveries in science, and attainments in literature and the arts, have merited the gracious consideration of their sovereign and the gratitude of their country."

On the accession of Queen Victoria, in 1837, the subject of pensions was again considered; and a select committee of the House of Commons, appointed to inquire into the Civil List, recommended,—"That in place of granting a sum of 75,000*l.* for Civil List pensions, her Majesty should be empowered to grant in every year new pensions on the Civil List to the amount of 1200*l.*, these pensions to be granted in strict conformity with the resolutions of the House of Commons, of February, 1834." These views were adopted by the House, and embodied in the 1 Vic., c. 2, the words of the resolution being introduced into the Act. Since the accession of Queen Victoria, still greater force has been given to the spirit of the Act, in consequence of the recommendations of a select committee of the House of Commons, appointed in December, 1837, to inquire how far the pensions charged on the Civil List, as settled on the accession of William IV., ought to be continued, "having due regard to the just claims of the parties and to economy in the public expenditure." This committee after a searching and protracted inquiry into the merits of each case on the Pension List, recommended the immediate suspension of several pensions, to be regranted on the responsibility of the government, should the circumstances of the parties render it necessary; others they considered should determine at an earlier period than specified in the original grant; and for several pensions, they considered it unadvisable to make any future provision. In their report, dated July, 1838, the committee recommended that in the case of all future Civil List pensions, the reasons and motives of the grant should be set forth in the warrant of appointment; that in pensions granted for services to others than the individual by whom the services were rendered, care should be taken, if these pensions are granted for younger lives, that is, to the sons or daughters of the individual entitled to the pension, that no undue increase of charge should be made; and that such grants should be avoided, except under very peculiar circumstances: they recommended also that pensions for the relief of distress should be granted only on the condition of their ceasing when the circumstances of the parties no longer require their continuance; that all pensions should be held liable to deduction or suspension in the event of the parties being appointed to office in the public service; that under no circumstances should the mere combination of poverty with the hereditary rank of the peerage be considered as a justification of a grant of pension. The committee also recommended that, in order to avoid any possible doubt or misconception hereafter, enactments should be made with respect to the Irish and Scotch revenue analogous to those contained in the English statute of 1 Anne.

Besides the pensions on the Civil List, the regulation of which at different periods has been referred to above, there are vast sums annually appropriated by parliament to the payment of pensions of another description. Thus in 1860-1 the sum of 1,063,371*l.* was voted on account of the out-pensioners of Chelsea Hospital, 58,469 in number; 232,764*l.* to the out-pensioners of Greenwich; 135,785*l.* to 2478 widows of officers of land-forces; and to officers in each of the civil departments of the government large sums are annually paid in pensions and superannuation allowances. The half-pay to retired officers of the navy and army may also be considered in the light of a pension. The Civil List pensions in the year ending June 20, 1860, amounted to 1500*l.*, divided among twenty-two recipients.

PENSIONARY, GRAND, was the name generally given to the first magistrate of the state or republic of Holland, which was a member of the confederation of the Seven United Provinces of the Netherlands. The Pensionary was the president of the council of states or legislature of Holland, and he was at the same time the first minister of the republic, and transacted business with foreign powers, like the Avoyer of Bern and other Swiss cantons. He was elected for five years, but was generally confirmed indefinitely, and often for life. He was also, in virtue of his office, the perpetual deputy of the state of Holland to the assembly of the states-general of the United Provinces, of which he was a most influential member, in consequence of the superior importance of the province of Holland. His name was derived from the pension which was attached to his office. He was also styled advocate-general to the states of Holland. The individual chosen for this high office was a person well versed in the science of the law, and he is styled by Grotius "Adsessor Jurisperitus." The various towns of Holland and Zealand had also each their pensionary, or chief municipal magistrate.

PENSTOCK, a kind of small sluice or floodgate, employed to retain or let go at pleasure the water of a mill or other pond. A cut of a simple form of penstock sluice is given under Irrigation. [Sluice.]

PENTACHLORXYLON ($C_{10}H_5Cl_3O_4$). One of the chlorinated products of the decomposition of creasote.

PENTACHORD, an ancient Greek musical instrument, which had, as the word implies, five strings. The term also signified a scale of five sounds.

PENTATEUCH (*Πεντάτευχος*, from *πέντε*, "five," and *τεῦχος*, "a volume") is the Greek name of the first five books of the Old Testament, which are called in Hebrew תּוֹרָה, "the law." The Hebrew copies of the Pentateuch form one volume; the division of it into five books is first mentioned by Josephus, and seems to have been made either by the Septuagint translators, or before their time, and after the return of the Jews from Babylon.

The five books of the Pentateuch have been treated of under Genesis, Exodus, Leviticus, Numbers, and Deuteronomy.

With regard to the Pentateuch in general, it has never been doubted, till at a recent period, that Moses was its author. The following are the chief arguments for its genuineness:—1. It is repeatedly asserted in the book itself that Moses was the author, and that he wrote it at the command of God. This assertion is made with regard to the whole book (Deut. i. 5; xxxi. 9-13, 22, 24-26), and to separate parts of it (Exod. xvii. 14; xxiv. 4, 7; xxxiv. 27; Numb. xxxiii. 1, 2). And in the recapitulation of the law which Moses makes in the book of Deuteronomy, he frequently speaks of "the law," "this law," "the book of the (or this) law," "the book of religion;" by which expressions we cannot fairly understand anything except either the whole Pentateuch, or that part of it which was already composed. (Deut. i. 5; iv. 44-45; xvii. 18, 19; xxviii. 58-61; xxix. 19, 20, 27, 29; xxx. 10.) 2. In all ages of the Jewish history, from the time of Joshua downwards, the Pentateuch was received as the divinely inspired composition of Moses. Thus we read repeatedly in the Old Testament of "the law," "the law of Moses," "the law of Jehovah," "the law which God gave by Moses," "the book of the law." (Josh. i. 7, 8; xxiii. 6; xxiv. 26; 1 Kings ii. 3; Psalms i. 1; and many other passages, which are collected in Rosenmüller's 'Scholia,' and Jahn's 'Introduction.') Besides these direct testimonies, the existence and authority of the Pentateuch among the Israelites are proved by the fact that the institutions which it contains were always observed as the laws of their nation, and that the sentiments of the Psalmists, the maxims of the Book of Proverbs, and the reproofs and exhortations of the prophets, are all exactly in agreement with the spirit of those institutions. 3. The internal evidence is strongly in favour of Moses being the author. The language of the book of Deuteronomy is that of an aged man addressing the people whom he had governed for forty years, appealing to their past experience, and speaking with all the earnestness of a man on the verge of death. If these characteristics are of any weight to show that the speaker and the writer of this book were the same, then we are supplied with an argument for the genuineness of the *whole* Pentateuch; for the book of Deuteronomy supposes the previous composition of Exodus, Leviticus, and Numbers, as these do that of Genesis. The information contained in the Pentateuch on subjects of history and geography (especially with reference to Egypt and Arabia), on natural history, diseases, the arts, and military science, agrees with all the notions we can form of the state of things at that remote period, and with what we should expect from a man who, like Moses, had been liberally educated at the Egyptian court, and had been engaged for forty years in leading a whole nation through the wilderness. The language of the Pentateuch is the most ancient known form of Hebrew. The style of the songs which are contained in it possesses that plain sublimity which generally characterises the first stage of a nation's poetry. The style of the narrative is better than that of any other Hebrew work, as we might expect from a highly educated man like Moses; and it is not more varied than can be accounted for by the different subjects treated of, and the intervals at which the different parts were written. The arrangement of the matter is not that which would be adopted by a person digesting into one book previously existing tales and laws; but it is such as we might expect from one exposed to frequent interruptions in his work, and who recorded each event as it occurred, which answers to the position of Moses. The selection of the materials appears to have been made on the principle of recording those things which were connected with the legislation which was the chief work of Moses; while of the laws themselves, some are repeated more than once, and others altered in the course of the work; all indicating that the legislator and historian were the same person.

It is true that there are passages in the Pentateuch which could not have been written by Moses. But there is no difficulty in explaining these passages as interpolations, inserted by a copyist with a view to make the author's meaning clearer. The following passages have been placed in this class; but some of them may be explained otherwise:—Deut. i. 1-4; iv. 44-49; Exod. vi. 13-29; vii. 7; xi. 1-3; Deut. ii. 10-12, 20-23; iii. 9, 11, 13-14; x. 6-9; Numb. xxxii. 41; Deut. iii. 14; Numb. xii. 3. To these may be added the 34th chapter of Deuteronomy, which, as it contains an account of the death and burial of Moses, was not written by himself. In some parts, however, of his narratives, Moses appears to have made use of previously existing documents, especially at the beginning of the book of Genesis. [Genesis.]

The Pentateuch was the only part of the Old Testament which the Samaritans received; and as, from feelings of national animosity, they held no intercourse with the Jews, their copies of the Pentateuch were preserved independently of the Hebrew copies. The Samaritan Pentateuch is mentioned by several ancient writers; but it was unknown in modern times till copies were obtained from the east by Archbishop Usher and Pietro della Valle. It was printed from the copy procured by the latter in the Paris Polyglot of Morinus, from which it was reprinted in Walton's Polyglot. It was also edited by Dr. Blayney in Hebrew characters, at Oxford, 1790. The original is in the Samaritan or old Hebrew character.

The Samaritan Pentateuch is quite entitled to rank with the Hebrew as an independent source for settling the sacred text. In some places it gives readings manifestly superior to those of the Hebrew. In many passages, in which it differs from the latter, it agrees with the Septuagint. Its chronology differs from that of the Hebrew Pentateuch. (Hales's 'Analysis of Chronology,' vol. i., p. 272.) In Deut. xxvii. the Samaritan differs from the Hebrew by having Ebal for Gerizim, and *vice versâ*. This has been regarded as an intentional corruption, made for the purpose of humouring national prejudices; but Dr. Kennicott has shown good reasons for preferring the Samaritan to the Hebrew in this case. ('Diss.' ii., pp. 20-165.)

The authenticity of the Pentateuch is also substantiated by passages in the later books of Holy Scripture, showing that there had been an uninterrupted belief in its authenticity. Thus it is quoted in 2 Kings xiv. 6, and xxiii. 2; 2 Chron. xxxv. 6; Ezra iii. 2, and vi. 18; Nehemiah i. 7; Amos ii. 9 and 10; Isaiah i. 9 and 14; and Micah vi. 5, where the books of Moses are directly quoted or alluded to. Christ and his apostles also acknowledge their authority by quoting them. Thus we have all the evidence of their authenticity that the nature of the case admits.

An account of the institutions recorded in the Pentateuch has been given under Moses, in Biog. Div.

(Rosenmüller, *Scholia in Vet. Test.*, vol. i., *Proleg. in Pent.*, and others quoted by him; Jahn, *Introd. in Lib. Sac. Vet. Foed.*; Hengstenberg, *Die Authentie des Pentateuchs*, 1836; Graves's *Lectures on the Pentateuch*; Bp. Marsh's *Authenticity of the Five Books of Moses vindicated*; Horne's *Introduction*, vol. i.; and Blunt, *Veracity of the Five Books of Moses.*)

PENTATHIONIC ACID. [Sulphur.]

PENTECOST, one of the three great Jewish feasts, so called because the day on which it began was the fiftieth (ἡ πεντηκοστή) from the second day of the Passover. It was also called the Feast of Weeks, from its falling at the end of a series of seven weeks, reckoning from the Passover, and also the Feast of the Harvest. It was a feast of thanksgiving for the harvest, at the end of which it fell, and among the sacrifices appointed for it were some of the first-fruits of the harvest. This festival lasted eight days. The laws relating to it are contained in Exod., xxiii. 16; xxxiv. 22; Levit., xxiii. 15–21; Numb., xxviii. 26–31; Deut., xvi. 9–12.

PENUMBRA (incomplete shade), that portion of space which, in the eclipse of a heavenly body, is partly, but not entirely, deprived of its light. In a solar eclipse, as long as any part of the sun is visible, the parties observing are in the penumbra, and not in the *umbra*, or complete shadow.

PEPPER-CORN RENT. [Rent.]

PEPPERMINT, ESSENTIAL OIL OF. Obtained by submitting the fresh herb [Mentha *piperita*, in Nat. Hist. Div.] to distillation with water, in the manner already described. [Essential Oils.] It is colourless when first prepared, but gradually acquires a yellow tint; has a characteristic, pungent, aromatic taste, and a peculiar odour, resembling that of the plant. Several varieties of it exist in commerce. [Mentha Piperita.]

Oil of peppermint consists of a camphor, or stearopten, and a liquid portion, or elæopten. The latter has not been minutely examined. English oil contains but little stearopten; American oil yields a considerable quantity; while the Chinese variety is wholly stearopten.

Peppermint camphor ($C_{20}H_{20}O_2$), as the stearopten is called, forms colourless prismatic crystals, is fusible at 87° Fahr., and may be volatilised without undergoing decomposition Its boiling point is 406·4; vapour density, 5·82. It is only slightly soluble in water, but readily so in wood spirit, alcohol, ether, and bisulphide of carbon, and tolerably so in oil of turpentine. Phosphoric acid converts it into MENTHENE.

Oil of peppermint is much adulterated with turpentine. The latter can generally be detected by the nose; while the pure oil is distinguished from the other mint oils by the deep red-brown colour which is imparted to it by chromate of potash.

PER. A prefix used in chemistry. [CHEMICAL NOMENCLATURE.]

PERAMBULATION. A perambulation is a walking through or over ground for the purpose of settling boundaries. A perambulation of a parish for this purpose is made by the minister, churchwardens, and parishioners in Ascension-week, at periods varying from one to three years. Usage will justify the parishioners in following the boundary over any man's land. Manors and lordships also are or may be perambulated: and there is a writ De Perambulatione faciendâ, which ought to be sued with the assent of both parties when they are in doubt about the bounds of their lordships or manors. The writ is addressed to the sheriff, who is to execute it and make his return to the justices at Westminster on a certain day; or to the justices of assize, under his seal, and the seals of those who make the perambulation with him. The king may direct the writ to other persons to make the perambulation, as well as to the sheriff. This perambulation made by assent binds the parties and their heirs. But unless both parties who assent to the perambulation are tenants in fee-simple, it seems that the perambulation shall not bind him who is in reversion.

Questions of boundaries are now generally determined, however, by actions of trespass or ejectment.

It was an old Roman practice at the time of the Terminalia, in the month of February, to perambulate the boundaries of a district or community. The original boundaries of the territory of Rome, which extended six miles from the city, were perambulated at the Terminalia; the boundaries between private properties were also perambulated at the Terminalia, and the usual religious offerings were made. This ancient and simple mode of preserving boundaries probably fell into disuse as the land-surveyors became more skilful, and the records of boundaries were better kept. It is stated that the practice fell into disuse with the establishment of Christianity. But this is not probable. The religious ceremonies might be changed or dropped: but the fact of perambulations being still kept up in this country in the case of parishes, leads to the conjecture that the practice extended from Rome to other countries which the Romans occupied, and was retained in some form among the Christianised people in the provinces.

PERAMBULATOR, an instrument in general use for measuring distances on roads, for settling disputes concerning the charges of the drivers of hack-carriages, and for other purposes. It consists principally of a wheel upon which it runs, and an index which shows the number of turns of such wheel reduced into miles, furlongs, poles, and yards.

The carriage or stock is made of wood, and is about 3 feet long. At one end is a handle for the person who uses it, and the other is furnished with sockets in which the axle of the wheel turns; this end of the stock has the centre part removed, by which are left two arms between which the wheel works. Upon the stock and just in front of the handle is the dial-plate, with its two hands by which the distance is registered. The wheel is 8 feet 3 inches, or ½ pole, in circumference. Upon one end of the axis of this wheel is a small pinion, which works into a similar pinion at the end of a rod which passes up the stock or carriage to the works beneath the dial-plate. Motion is communicated by means of this rod to a worm or micrometer-screw, which turns once round for each revolution of the carriage-wheel of the perambulator. This worm works into a wheel of 80 teeth, which is moved forward one tooth for every ½ pole, and carries a hand or index, which makes one revolution for 40 poles or one furlong. On the axis of this wheel is a pinion of 8 teeth, which works into a wheel of 40 teeth, and on the axis of this second wheel is a pinion of 10 teeth, which moves a wheel of 160 teeth. This last wheel carries another hand, which makes one revolution for 80 of the former. These hands are arranged in the same manner as the hour and minute hand of a watch, so that the three circles on the dial-plate are all concentric. The first of these circles is divided into 220, and the second into 40, the number of yards and poles contained in a furlong; the figures on these circles are read off by the first-mentioned index, that which is attached to the wheel of 80 teeth. The third circle is divided into 80, the number of furlongs in 10 miles, and to this circle belongs the index attached to the wheel of 160 teeth. The distance is ascertained by reading off the figures in the reverse order in which the circles are given above: divide the number on the first circle by 8, and you will have the distance required in miles, furlongs, poles, and yards.

The instrument is furnished with a stop or strap, so that after the distance is measured, the perambulator may be conveyed without the index being altered.

Unlike the pedometer, it requires no regulating, and the only risk of its giving the distance incorrectly, if well constructed, is in passing over rugged and uneven roads, which will of course cause the index to show more than the true distance. In general, however, for short distances, this error is very trifling.

When about to commence a measurement, the wheel should be turned round until the first-mentioned index points to 220 on the circle of yards. Some are provided with a click and racket, by which this may be done with much less trouble than by the wheel.

There are other instruments for the same or similar purposes, bearing different names, *waywiser* and *odometer;* but the construction of all of them is very similar.

Waywiser is the name generally given to that form of the instrument which is applied to a carriage, in which, by a slight adaptation to one of the wheels of the carriage, the instrument is made to register the number of turns of such wheel, in the same manner as the perambulator.

PERCEPTION is that power or act of the mind by which it holds communication with the external world. It is distinguished from *conception* by the circumstance that its objects are in every instance supposed to have an actual existence. We may conceive things that have no reality, but we are never said to perceive such things. Perception differs from *consciousness* in that it takes cognisance only of objects without the mind. We *perceive* a man, a horse, a tree; when we think or feel, we are *conscious* of our thoughts and emotions. It is further supposed in perception that the objects of it are present. We can *remember* former objects of perception, but we do not perceive them again until they are once more present. Besides the sense which has been explained, the term perception is sometimes analogically employed in common speech in reference to truths the evidence of which is certain. Thus we may perceive the truth of a mathematical proposition. But Mr. Hume is perhaps the only writer of eminence who designedly applies the word in a metaphysical disquisition with a meaning different from that which has been here assigned to it. By him it is applied indiscriminately to all the operations and states of the mind; passions being designated perceptions, and the acts of memory and imagination converted into so many acts of perception. Such latitude of phraseology confounds under one general name things essentially distinct, and tends to introduce vagueness and inaccuracy into a department of philosophical investigation where definiteness and precision are peculiarly indispensable.

The distinction between things *perceived* (*αἰσθητά*) and things *conceived* (*νοητὰ*) was familiar to the Greek philosophers and to their Latin expositors, of whom Cicero expresses the former class of things by the phrases "quæ sunt," "quæ cerni tangive possunt;" and the latter by "quæ tangi demonstrarive non possunt, cerni tamen animo atque intelligi possunt," and gives examples of each. ('Top.' v.)

The perceptive faculty is exercised through the instrumentality of the senses. We see by means of the eye, and hear by means of the ear, and so in reference to the other senses. An individual in whom these organs are wanting or defective, will either not perceive at all, or perceive imperfectly. In order to perception it is requisite that an impression should be made on the organ of sense, either by the direct application of the object, or through some medium that communicates with the object and the organ. Thus an immediate application is necessary with regard to the senses of taste and touch; but only an intermediate one with regard to those of sight, hearing, and smell. The impression made on the organs of sense affects the nerves, and is by them conveyed to the brain. The necessity of this communication is ascertained by observation. If the nerve appropriated to any organ be cut or tied hard, no perception takes place; and the same result is noticed in certain disordered conditions of the brain, even though the organs of sense and the nerves perform their respective functions. When however the conditions that have been specified are complied with, perception ensues.

Various theories have been formed to explain the functions of the nerves and brain in connection with perception. It was imagined by the ancients that the nervous fibres are tubular, and filled with a subtile vapour named animal spirits; that the brain is a gland by which this ethereal fluid is secreted; and that by means of it the nerves perform their office. (Reid, 'Essay' ii., ch. iii.) Des Cartes, who adopted this hypothesis, has described with great minuteness how all mental operations and movements are accomplished through the agency referred to. Dr. Briggs, Newton's instructor in anatomy, was the first who proposed a new doctrine on this point. He maintained that the nerves operate by vibrations, like musical chords, and thus conduct impressions to the brain. Newton himself ('Opt.,' qu. 23) appears to have been inclined to a notion of this kind, and the suggestions relating to it thrown out by him as a query were afterwards amplified and defended by Hartley. The latter supposed that "external objects impressed on the senses occasion, first in the nerves on which they are impressed and then in the brain, vibrations of the small and, as one may say, infinitesimal medullary particles;" and that these vibrations "are excited, propagated, and kept up partly by the ether, that is, by a very subtile elastic fluid: partly by the uniformity, continuity, softness, and active powers of the medullary substance of the brain, spinal marrow, and nerves." ('Observations on Man,' part i., prop. 4, 5.) Both Des Cartes and Hartley believed that by the action of the nerves in the manner described by them, images of external objects were formed in the brain.

It is scarcely necessary to remark concerning these hypotheses that they are totally destitute of foundation. A sound theory must assign real and not imaginary causes for the phenomena which it professes to explain; and such causes must have a manifest competency to the effects ascribed to them. But the hypotheses in question entirely want both of these essentials. Who can prove the existence of the animal spirits of Des Cartes, or the vibrations of Hartley; or, granting their existence, who can show any correspondence between them and the formation of images in the brain? All we can affirm with certainty respecting the means of perception is, that, under certain circumstances, that is, when an impression is made on the bodily organs and communicated by the nerves to the brain, perception takes place. The impressions so communicated are the occasions of the mind perceiving, but we can assign no reason why it should do so under these circumstances invariably, and not under any other, further than that such is the constitution of our nature.

If the act of perception be examined, it will be found that we obtain by it a certain amount of information respecting the object perceived. We discover that it has particular qualities, as for example, that it is extended, that it has figure, that it is hard or soft, rough or smooth, &c. The notion thus formed may vary in respect of distinctness in all possible degrees. In the light of twilight a body is discerned more obscurely than in the full light of noon day; and more obscurely still in proportion as the darkness deepens. The notion we get of an object by perception is accompanied by an irresistible and immediate conviction of its real existence. An object may indeed be perceived so indistinctly as to leave us in doubt whether it be real or not. If it be very distant, or involved in darkness, this may happen. But when it is plainly perceived, there is, along with the perception, a perfect conviction of its reality. We can no more doubt of its existence than we can of our own. And this conviction is immediate. It is not the result of a process of reasoning founded on our perceptions, but inseparably connected with them, and as instantaneous as the assent rendered to axiomatic truths. It may be also remarked that the belief in the existence of the objects of perception is not more immediate and deeply rooted than is the belief that they exist externally to us. They do not seem to have their place in the mind itself, but to exist independently of it altogether. These statements accord with the universal experience of mankind, and may be verified by all who choose to bestow the slightest attention on the intimations of consciousness.

It would be a tedious as well as a useless task to dwell minutely on the numerous theories that have been framed of perception. In certain important particulars nearly all of them coincide; while in others, equally if not more important, they are for the most part at variance.

Democritus taught that perception was the result of the impressions made on the organs of sense by images (εἴδωλα), which constantly emanated from bodies, and varied according to the conformation of their originals. (Plut. 'Plac/Phil.,' l. iv., ch. 8, &c.)

Plato, in the seventh book of his 'Republic' (ad init.) illustrates the manner in which we perceive objects, by the figure of a cave, in which men lie bound, so that they can turn their eyes only to one part of it, where rays from a distant light stream in, and shadows of bodies, supposed to pass between them and the light, are beheld, the bodies themselves being invisible. He thus conceived that we perceive only the shadows of things, and not things themselves.

This opinion of Plato was substantially the same with that of his scholar Aristotle, and of the Peripatetics generally. Aristotle ('De An.,' l. iii., c. 2, 3) taught that as the senses cannot receive material objects themselves, they receive their images. These images are the only objects of perception to the mind. As impressed upon the senses, they are termed sensible species; more spiritualised, they become objects of memory and imagination, and are termed phantasms; still further refined, so as to be objects of science, they are named intelligible species.

The theory of Epicurus was little other than a modification of that of Aristotle. He supposed that bodies are continually sending off from their surfaces slender films or spectres of such subtlety that they easily penetrate by the senses to the brain. (Lucret., l. iv., v. 34, 46, &c.)

Locke employs an illustration of the manner of perception that appears to have been borrowed from that of Plato:—"Methinks," he says, "the understanding is not much unlike a closet wholly shut from light, with only some little light opening left to let in external visible resemblances, or ideas of things without. Would the pictures coming into a dark room but stay there, and be so orderly as to be found upon occasion, it would very much resemble the understanding of a man in reference to all objects of sight and the ideas of them."

The similitude of Locke, or rather of Plato, may be applied to all the systems of perception that have ever been formed, by merely substituting ideas, and, in the case of Hume, impressions, for what were anciently denominated species and phantasms. All these theories agree in maintaining that images are the only immediate objects of perception to the mind. Hume, Berkeley, and others indeed hold that these are the exclusive objects; but the common hypothesis admits the existence of things of which these are but the representatives, and which we mediately discern. It may be sufficient to remark concerning these opinions, that they are diametrically opposed to the testimony of our own consciousness. Instead of informing us that images alone are the direct objects of our perception, consciousness intimates nothing respecting images at all. Unless its representations are altogether deceptive, it is not things within the mind, but things external to it, that we perceive; not images of objects, but the very objects themselves. This is testimony to which we yield instinctive credence. It is too cogent and unquestionable to be set aside by reasoning of any kind, far less by reasoning based upon certain imagined relations subsisting between matter and spirit which we are incapable of apprehending, and the application to mind of laws which apply solely to the objects of physical investigation.

One observation, intentionally deferred, remains still to be made respecting perception, namely, that it is greatly modified by habit and by the cultivation and development of the other powers. Thus the perceptions of a man and those of a child, both contemplating a piece of complex machinery, the one being aware of its principles and arrangements, the other completely ignorant of them, must in some respects considerably differ. In like manner the perceptions of a blind man, by means of those organs of sense which are unimpaired, are distinguished in many particulars from those of the individual who has never been without the faculty of vision. Numerous instances of a similar kind might easily be specified. A full account of acquired perceptions, such as those alluded to, is still a desideratum in this department of philosophical inquiry.

PERCH or POLE. This measure, though now mostly used as a square measure (a perch usually meaning a square perch, or a square of a perch in length and breadth), was originally a measure of length, arising out of the custom of measuring small portions of land by a staff or pole. The word *pertica*, from which it comes, means a wooden staff. But the pole with which land was measured not only differed very much in different countries, but in different parts of the same country. Ducange and his editors find records of the use, in different parts of England and France, of perches of 7½, 10 (the oldest English), 12, 15, 16, 18, 20, 21, 22, 25, and 27 feet. Here is but another instance (as in MILE and LEAGUE) of the tendency of measures to lengthen. Forty perches (quarantena), under the name of forty-long or furlong, became a common measure of length; and a piece of land forty perches long and one deep, was called *perticata*. (Spelman, cited by Ducange.) Thus the perch and furlong, though afterwards received into the system of measures which ends with the mile, originally formed no part of it whatever. [MILE.]

By an early statute, entitled 'Compositio Ulnarum et Perticarum,' the perch was fixed at 16½ feet, or five yards and a half; and four perticatæ (though that word is not used) were defined as an acre.

A perch is the quarter of a chain, and a square perch contains 30¼ square yards.

PERCHLORIC ACID. [CHLORINE.]

PERCHLORINATED QUINONE. [QUINONE.]

PERCHLOROXYNAPHTHALIC ACID ($C_{20}HCl_5O_6$). *Chloroxynaphthalesic acid.* When perchloroxynaphthyl is placed in contact with potash it is instantly transformed into a magnificent carmine-coloured body, which is the potash salt of this acid. The acid itself is yellow, insoluble in water, but soluble in boiling alcohol. The ammonia salt, which is of a bright red, is, like the potash salt, quite insoluble in water. This acid may be regarded as pentachlorinated alizarine.

PERCHLORRUBIAN. [MADDER, COLOURING MATTERS OF.]

PERCUSSION, CENTRE OF, the point of a system which moves about a fixed axis, at which a force may act in such a manner as to produce no pressure on the axis. Its distance from the axis is the same as that of the centre of oscillation. [OSCILLATION.]

PERCUSSION, in medicine, is the method of eliciting sounds by striking the surface of the body, for the purpose of determining the condition of the organs subjacent to the parts struck.

This means of diagnosis was first employed by Avenbrugger in the middle of the last century; it was afterwards extensively adopted by Corvisart in investigating the diseases of the heart, but its value, like that of all the other branches of auscultation, was not fully appreciated till Laennec made them the subject of his peculiar study. Since his time, its value has been considerably enhanced by the labours of M. Piorry.

Everybody knows that when a hollow body is struck, there is a vibration produced in the air within it, which being communicated through the walls to the external air, produces a ringing sound, whose tone varies with the size of the hollow body, the material of which it is composed, and many other circumstances; but that if the same body be filled with a fluid or a nearly solid substance, no other sound is produced than that which results from the striking together of two solid bodies of the same materials as the wall of the cavity and the substance with which it is struck. On these circumstances the practice of percussion is based. If any part of the body beneath which there is a hollow organ, or one containing air in tubes, be struck, a resonance is produced; if any part which lies over a solid or a fluid be similarly struck, the sound emitted is merely the dull noise of two solid and rather soft bodies.

The modes of employing percussion are various. The simplest and most convenient is to place one finger of the left hand flat upon the part to be examined, and to strike it lightly, but rather sharply, with the ends of the three first fingers of the right hand set close together on the same level. Instruments called pleximeters have been invented by M. Piorry and others; they are composed of small plates of cork, india-rubber, light wood, or ivory, which being held by their edges or by a handle, are placed on the part to be examined, and struck with the fingers, or with a small hammer. Whether the hammer and pleximeter or the fingers are used, care should be taken that the blows are always given with the same or an exactly estimated degree of force, and that they should fall perpendicularly to the surface of the organ to be examined.

Percussion is chiefly employed in the diagnosis of diseases of the lungs, heart, and abdominal organs. [PHTHISIS; HEART, DISEASES OF, &c.]

The lungs being chiefly composed of tubes and cells filled with air, there is a certain degree of resonance when the chest over any part of them is struck; but the character of the sound varies somewhat both in intensity and in tone, according to the part of the chest examined, and the thickness and softness or hardness of its walls: in all parts however, when the lungs are healthy, there is resonance. When however the lung is covered by fluid, or has the quantity of air in it lessened by obstruction of the air-tubes, or by deposits of fluid or solid substances in or around the cells, the resonance of the chest directly over the part affected is diminished or entirely lost, and in extreme cases the only sound obtained by percussion is the dull sound of the contact of the fingers with the wall of the chest. When, on the other hand, the air-cells are dilated, and the lungs contain a greater proportion of air than is natural to them, as in emphysema of the lungs, the resonance of the chest is in a corresponding degree increased. The various degrees between perfect dullness, such as occurs when the lung is covered by fluid [HYDROTHORAX], or rendered solid by inflammation [LUNGS, DISEASES OF], or by tubercular deposition [PHTHISIS], and the highest degree of resonance in emphysema are numerous, but are of course appreciable only by a very practised ear and hand. To them the evidence they afford is scarcely less valuable than that obtained from the use of the stethoscope, with which the practice of percussion should, in all diseases of the chest, go hand in hand.

In the healthy state, the chest, when struck over the region of the heart, emits a duller sound than that which proceeds from the rest of its walls. In the natural size of the heart this region occupies a space of an inch and a half or two inches square, situated just to the left of the sternum, at the level of the fourth and sixth ribs. When either the heart itself is enlarged, or a quantity of fluid is accumulated in the pericardium, the extent of this less resonant region is increased in a corresponding degree; but the changes of sound which it emits depend greatly on the coincident condition of the lungs, and the extent to which their anterior margins overlap the front of the heart.

By percussion on the abdomen one may obtain information, approximating to truth, of the size of all the solid organs, by the extent of the dullness of sound in their respective regions; and of the degrees of inflation, and even of the nature of the contents of the digestive canal and the peritoneal cavity, whether solid, liquid, or aëriform; but the evidence thus obtained is on the whole less definite in the diseases of the abdominal organs than in those of the heart and lungs.

(M. Piorry, *De la Percussion mediate*, Paris, 1828; Bennett, *Introduction to the Study of Clinical Medicine*, 1860; Weber, *On Auscultation and Percussion*, translated by Cockle, 1854.)

PEREIRIN. An alkaloid of febrifuge qualities, but of uncertain composition, found in the bark of the *Vallesia inedita*.

PERFUMERY, considered as a branch of manufacture, is chiefly chemical in its nature; but its chemistry is of that peculiar kind which relates almost wholly to the *odour* of substances, whether animal, vegetable, or mineral,—whether natural or artificial. The relations of the substances to light and colour, or to solidity and liquidity, are of quite secondary importance; so long as the invisible odour-bearing particles are given off, and conveyed by the air to the organ of smell, all substances may take rank among perfumes—except, of course, such as yield an unpleasant odour. It is generally admitted that perfumes, if pleasant, exercise a cheering and exhilarating influence on the human system, and revive the spirits when fatigued or depressed. The connection between the brain and the organ of smell is too close to allow the former to be quite uninfluenced by anything which affects the latter.

Without touching here upon the physiological or medical relations of perfumes, we shall say a few words concerning their production as a branch of trade. Linnæus divided scents into seven kinds, Touray into five, and De Haller into three. Mr. Rimmel, himself a perfumer, who read a paper on this subject before the Society of Arts in 1860, groups the scents mostly used in perfumery under eighteen kinds, represented by the following types:—rose, jasmine, orange-flower, tuberose, violet, balsam, spice, clove, camphor, sandal, citrine, lavender, mint, aniseed, almond, musk, amber, and fruit flavour. The principal branches of the perfumery trade, connected with these eighteen kinds of scents, are the making of scented soaps, the compounding of perfumes, and the production of numerous minor articles for the toilet. Perfumed soaps are made on the same general principle as common soap, but in smaller quantity, with greater care, and with the addition of certain odoriferous substances. The removal of the excise restrictions has been the cause of much improvement in this art, the perfumer being at liberty to make more varied experiments than were before permitted. The perfumed liquids and pastes are very numerous. The basis of most of them is obtained by treating with alcohol the pomade or oil extracted from flowers. There are also many toilet-waters, such as eau-de-cologne, and the once-famous Hungary water, manufactured chiefly with an alcoholic basis. Lavender-water was formerly distilled with alcohol from fresh flowers; but it is now made more economically by digesting the essential oil in alcohol.

The substances mostly used in the manufacture of perfumery are of *animal* origin, such as musk, civet, and ambergris; *flowers*, such as jasmine, rose, orange-flower, violet, jonquil, narcissus, &c.; *herbs*, such as the leaves and stalks of peppermint, fennel, thyme, marjoram, spike, rosemary, verbena, &c.; *fruits* of the citrine kind, such as orange, lemon, and cedrat; *spices*, such as cassia, cinnamon, cloves, mace, and nutmeg; *woods*, such as sandal-wood, rosewood, cedar-wood, and sassafras; *roots*, such as orris-root and the Indian kus-kus; *seeds*, such as aniseed, dill, and carraway; and *gums*, such as benzoin, styrax, myrrh, camphor, and several balms or balsams. Most of the odoriferous principles are extracted by distillation; but the aroma of flowers is now very often obtained by the agency of fatty bodies. Scented pomades and oils are produced either by maceration or by absorption; the former for the less delicate flowers, and the latter for such as the jasmine and tuberose, which cannot bear a high degree of heat without losing their scent. Mr. Rimmel states that at three towns in the South of France there are no less than 100 firms engaged in obtaining pomades and essential oils from flowers, consuming annually the following quantities and value of flowers:—

1,760,000	lbs.	Orange flowers	£32,000
550,000	,,	Rose flowers	10,000
110,000	,,	Jasmin flowers	6,000
66,000	,,	Violets	7,000
66,000	,,	Cassia	10,000
33,000	,,	Tuberose	3,000

The rose-water, orange-flower-water, scented pomades, and essential oils, obtained from these materials have a value of nearly 300,000*l.* M. Piver, of Paris, adopts a peculiar mode of obtaining the perfumes of plants by bringing a condensed current of air to bear upon the scented particles, and forcing them to combine with a kind of ointment. M. Millon, another French perfumer, extracts the aroma of flowers by means either of ether or sulphuret of carbon, both of which are powerful solvents.

The extent of this manufacture is much larger than is generally supposed. Mr. Rimmel states, from data which he has been able to obtain, that there are 40 manufacturing perfumers in London alone, employing from 20 to 100 hands each; that our imports of essential oils and perfumery materials reaches 200,000*l.* annually; that the retail value of all the perfumery made in the United Kingdom cannot fall far short of 1,000,000*l.* a year; and that there are 80 manufacturing perfumers in Paris, employing 2000 to 3000 hands. Mr. Rimmel gives the names, place of production, and form or condition, of about seventy substances employed by the manufacturing perfumer. The prices affixed to some of these are extraordinary—civet, 1*l.* per oz.; musk, 1*l.* 10*s.* per oz.; ambergris, 2*l.* per oz.; essential oil of *Acacia farnesiana*, 4*l.* per oz.; essential oil of jasmine, 6*l.* per oz.; while attar of roses, in its choicest and most concentrated form, runs up to 12*l.* per oz., or threefold the value of pure gold, weight for weight.

It is worthy of mention, that, although manufacturing perfumers, such as Mr. Rimmel in the paper above adverted to, and Mr. Septimus Piesse, in a recent volume relating to the subject, dwell chiefly on the obtaining of perfumes from flowers, fruits, and other pleasant substances; chemists are well aware of methods by which perfumes can be obtained in a very different way, and from substances which do not at all accord with the names given to the perfumes. Dr. Lyon Playfair, in his lecture on the Results of the Great Exhibition of 1851, said: "A peculiarly fœtid oil, termed fusel oil, is formed in making brandy and whiskey; this fusel oil, distilled with sulphuric acid and acetate of potash, gives the *oil of pears*. The *oil of apples* is made from the same fusel oil, by distillation from sulphuric acid and bichromate of potash. The *oil of pine-apples* is obtained from a product of the action of putrid cheese on sugar; or by making a soap with butter, and distilling it with alcohol and sulphuric acid; and is now largely employed in England in making pine-apple ale. *Oil of grapes* and *oil of cognac*, used to impart the flavour of French cognac to British brandy, are little else than fusel oil. The artificial *oil of bitter almonds*, now so largely employed in perfuming soap, and for flavouring confectionary, is prepared by the action of nitric acid. Many a fair forehead is damped with *eau de millefleurs*, without knowing that its essential ingredient is derived from the drainage of cowhouses." This lecture elicited some objections, on the ground that, although agreeable scents *may* be obtained from offensive substances, it does not follow that they *are* so in practice; but probably the manufacturer who went to such sources would not be likely to own it publicly.

PERIBOLUS. [TEMPLE.]

PERICARDITIS. [HEART, DISEASES OF THE.]

PERIGEE, the point of the moon's orbit in which she is nearest to the earth.

PERIHE'LION, the point of the earth's orbit in which it is nearest to the sun. [APHELION.]

PERI'METER, the circuit, or bounding line, of a plane figure; a term usually applied to rectilinear figures only, but without any particular reason for the restriction.

PERIOD, a name given to the recurring part of a CIRCULATING DECIMAL.

PERIODIC ACID. [IODINE.]

PERIODIC FUNCTIONS. The general consideration of periodic magnitude, that is, of magnitude which varies in such manner as to go through stated cycles of changes, each cycle being a reiteration of the preceding one, is the subject of TRIGONOMETRY. Though that science derives its name from the measurement of triangles (as geometry does from that of the earth), its resources have been cultivated and its methods expanded until no definition short of the preceding will express its object or convey an idea of its powers.

In the article cited will therefore be explained the mode of measurement applied to periodic magnitude: the present one is intended for nothing more than to point out a peculiarity of some classes of algebraic functions which has procured for them the name of *periodic* functions.

The calculus of FUNCTIONS considers only forms, and the operations necessary to convert one given form into another, or to satisfy equations in which some forms of operation are unknown. Periodic functions are those which, performed any given number of times on a variable, reproduce the simple variable itself. Thus $1 - x$ and $-x$ are periodic functions of the second order, since

$$1 - (1 - x) = x, \quad -(-x) = x.$$

Again, $1 : (1 - x)$ is a periodic function of the third order, since, if we begin with x, and write $1 : (1 - x)$ for x three times in succession, we end with x also—

$$x, \quad \frac{1}{1 - x}, \quad \frac{x - 1}{x}, \quad x.$$

Periodic functions are remarkable in the calculus of functions for the simplicity with which questions connected with them can be solved, when compared with the difficulty of solution of cases in which non-periodic functions enter. Their principal properties are here briefly pointed out: for further information, consult Babbage's 'Examples of Functional Equations' (appended to Peacock's 'Examples'), or the article on the Calculus of Functions contained in the 'Encyclopædia Metropolitana,' where further references will be found.

Let ϕx be a function of x; abbreviate $\phi(\phi x)$ into $\phi^2 x$; $\phi(\phi^2 x)$ into $\phi^3 x$, &c.: then, if ϕ be a periodic function of the nth order, $\phi^n x = x$.

Let r be one of the nth ROOTS of unity, then rx is the simplest periodic function of the nth order; but very simple ones of the form $(1 + bx) : (c - kx)$ may be obtained by making

$$k = \frac{b^2 - 2\,bc \cos\theta + c^2}{2(1 + \cos\theta)}$$

where θ means the nth part of any multiple of four right angles. For instance, if $n = 4$, θ may $= 90°$, and $\cos\theta = 0$, whence $k = (b^2 + c^2) : 2$; whence

$$\frac{2 + 2bx}{2c - (b^2 + c^2)x}$$

is a periodic function of the fourth order.

Let Θx be any function of x whatsoever, and $\Theta^{-1} x$ its INVERSE function, so that $\Theta\Theta^{-1} x = x$; then if ϕx be a periodic function, $\Theta\phi\Theta^{-1} x$ is also periodic. Thus $1 - x$ being periodic of the second order, so are $\log(1 - \epsilon^x)$, $\sqrt{(1 - x^2)}$, $\sin^{-1}(1 - \sin x)$, &c. &c.

Let $\Theta\phi\Theta^{-1} x$ be called a derivative of ϕx; then if ϕx and ψx be two periodic functions of the nth order, either can in an infinite number of ways be made a derivative of the other. Thus one of the ways in which $1 : x$ is a derivative of $-x$ is $\epsilon^{-\log x}$. Let $1, r, r^2, \ldots . r^{n-1}$ be all the n roots of unity, let P_0 be any function of x and y, and let P_1 be the same function of ϕx and ψy, P_2 of $\phi^2 x$ and $\psi^2 y$, &c. From the equation

$$\text{P}_0 + r\,\text{P}_1 + r^2\,\text{P}_2 + \ldots . + r^{n-1}\,\text{P}_{n-1} = 0,$$

find y in terms of x; say $y = \Theta x$. Then will $\psi y = \Theta\phi x$, or $\psi x = \Theta\phi\Theta^{-1} x$; that is, ψx is expressed as a derivative of ϕx.

For example, let $\phi x = -x$, $\psi x = 1 - x$, be the periodic functions, of the second order; then $r = -1$. Let $\text{P}_0 = ax + by$, then the preceding equation becomes

$$ax + by + (-1)(-ax + b\,\overline{1 - y}) = 0;$$

$$\text{or } y = \Theta x = \frac{b - 2ax}{2b}, \ \Theta^{-1} x = \frac{b - 2by}{2a}$$

$$\Theta\phi\Theta^{-1} x = \frac{b - 2a\left\{-(b - 2bx) : 2a\right\}}{2b} = 1 - x.$$

The periodic functions, as before observed, are those whose relations are most easily obtained. For example, let αx, βx, γx, be given functions of x, and ϕx an unknown function, to be determined by the equation

$$\phi x = \beta x + \gamma x \phi \alpha x.$$

If αx be not periodic, there are two difficulties in the way, each most frequently insuperable: first, the determination of some one solution of this equation; secondly, the determination of the INVARIABLE function of this equation, or the solution of $\psi\alpha x = \psi x$. But when αx is periodic, both difficulties can be overcome and a general solution given. Say $\alpha^n x = x$, then ψx is any symmetrical function of x, αx, $\alpha^2 x, \ldots . \alpha^{n-1} x$; and if B_0, B_1, &c., be βx, $\beta\alpha x$, &c., and $\text{C}_0\,\text{C}_1$, &c., be γx, $\gamma\alpha x$, &c., the general solution divides into two cases, in the first of which the solution does not depend on the invariable function.

The most general case gives

$$\phi\,x = \frac{\text{B}_0 + \text{C}_0\,\text{B}_1 + \text{C}_c\,\text{C}_1\,\text{B}_2 + \ldots + \text{C}_0\text{C}_1 \ldots \text{C}_{n-2}\text{B}_{n-1}}{1 - \text{C}_0\,\text{C}_1\,\text{C}_2 \ldots . \text{C}_{n-1}}$$

In this case the preceding is the most complete and only solution. But if C_0 and B_0, &c., be such that the numerator and denominator of the preceding both vanish, the general solution is

$$\begin{aligned} n\phi x = {} & (n - 1)\,\text{B}_0 + (n - 2)\,\text{C}_0\,\text{B}_1 + (n - 3)\,\text{C}_0\,\text{C}_1\,\text{B}_2 \\ & + \ldots . + \text{C}_0\,\text{C}_1\,\text{C}_2 \ldots \text{C}_{n-3}\,\text{B}_{n-2} \\ & + (1 + \text{C}_0 + \text{C}_0\,\text{C}_1 + \ldots . + \text{C}_0\,\text{C}_1 \ldots \text{C}_{n-2})\,\psi x. \end{aligned}$$

For demonstration and extension, see the article cited in the 'Encyc. Metrop.,' §§ 192-198, and 235.

PERIODS OF REVOLUTION. In the present article we simply describe the names, commencements, lengths, and uses of those periods which it is most requisite the reader should find distinctly explained in a work of reference, premising some explanation of the way in which comparison of different periods gives new periods.

By a period we mean a definite portion of time, beginning from a given *epoch*, or *æra*,* which, being repeated again and again, will serve to divide all time subsequent to the epoch (or precedent, if the repetitions be also carried backwards from the epoch) into equal parts, for the purposes of common reckoning and historical chronology. A period is then a finite portion of time used for measurement, just as a foot or mile is used for measurement of length.

Periods may be divided into natural and artificial; the former immediately suggested by some recurrence of astronomical phenomena; the latter arbitrarily chosen. Since, however, time cannot be preserved and handed down as if it were material, it is natural that the knowledge of artificial periods should be preserved by representing the number of natural periods which they contain; nor is it to be supposed that artificial periods were ever invented in a perfectly arbitrary manner, or were indeed ever anything more than convenient collections of natural periods.

When one period is contained an exact number of times in another, each recommencement of the larger one is also a recommencement of the smaller one; thus, the day being exactly twenty-four hours, if any one day begin at the beginning of an hour, all days will do the same. But if the smaller period be not a measure of the larger, a longer period may be imagined, which in this article we shall call a *cycle*, consisting of the interval between the two nearest moments at which the smaller and larger periods begin together. Thus, a week of seven days and a month of thirty days give a cycle of seven months or thirty weeks, these two periods being equal. If, however, the two periods can be measured by a larger number of days, the cycle may be made smaller; thus, a month of 30 days and a year of 365 days, or a month of 6 times five days, and a year of 73 times five days, would give a cycle of 6 × 73 times five days, that is of 6 years or 73 months.

When two natural periods are expressed by complicated fractions of days, the method explained in FRACTIONS, CONTINUED, will serve to show nearly how many of one period make up an exact number of the other. Thus the tropical, or common year being 365·24224 days, and the lunation being 29·53059 days, both approximate, it appears that 36,524,224 lunar months would be 2,953,059 years nearly. To reduce this long cycle to others more convenient for use, and as accurate as the number of figures employed will permit, proceed as in the article cited with the fraction

$$\frac{2{,}953{,}059}{36{,}524{,}224}$$

The quotients obtained are 12, 2, 1, 2, 1, 1, 17, &c., at which we stop, because the appearance of so large a quotient as 17, shows that the result of the preceding quotients is extremely near. The successive approximations derived from the first six quotients are—

$$\frac{1}{12} \quad \frac{2}{25} \quad \frac{3}{37} \quad \frac{8}{99} \quad \frac{11}{136} \quad \frac{19}{235}$$

Or 235 lunations make 19 years very nearly.

The period in which all others are expressed is the day, which is not, as many suppose, the simple time of revolution of the earth, but [DAY] the average time between noon and noon. To distinguish it from other days it is called the *mean solar* day.

The year, or the time between two vernal equinoxes, is not a uniform period, nor does the average of one long period give *precisely* the same as another. [YEAR.] For chronological purposes, however, it is useless to take account of this variation, and 365·2422414 days, the year of astronomers in our day, may be considered as more than sufficiently exact for any time. In fact the year is made to consist, in the long run, of 365·2425 days, and a cycle of 400 years is necessary to the complete explanation of this fraction. Supposing the years from A.D. 2001 to A.D. 2400, both inclusive, each fourth year is leap-year, beginning with 2004, except only 2100, 2200, and 2300, which gives in the 400 years 365 days to each year, and 97 intercalated days; while adding 97 days to 400 years, adds on the average 97-400ths or ·2425 of a day, to each year. As it is of considerable importance distinctly to comprehend an intercalated cycle, that is one in which fractions are disregarded until they amount to a unit, when they are corrected, to use a common phrase, in the lump, we put down the effect of the correction which is made in the year 1840, being leap-year. In 1836, immediately after the last intercalation was made, the sun was in the vernal equinox at about 39 minutes after 1 P.M. on the 20th of March, and the equinoxes then took place as follows :—

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* These terms are used synonymously by most chronologers: but some mean by *æra* the whole of the time which is measured from the *epoch*. The ear of the reader will perhaps be familiar with both of the phrases, "the 5th century *of* the Christian æra," and "the 5th century *after* the Christian æra."

1836	Sun in equinox	at $1^h\ 39^m$ P.M.	March 20
1837	,,	at $7^h\ 23^m$ P.M.	March 20
1838	,,	at $1^h\ 18^m$ A.M.	*March* 21
1839	,,	at $7^h\ 1^m$ A.M.	*March* 21
1840	,,	at $0^h\ 41^m$ P.M.	March 20

The intercalation of 1840 (but for which the sun would have come on the equinox at 41 minutes past noon on the *twenty-first*) has overdone the correction, bringing the equinox nearer to noon than in 1836 by 58 minutes. Now this over-correction of nearly an hour in four years is set nearly right by leaving out the correction three times in 400 years; a provision the necessity of which may be imagined, though its exactness cannot be appreciated from the preceding rough calculation.

The Gregorian year, therefore (or the year in the Gregorian reformation of the kalendar), is a portion of a cycle of 400 years of 365 days, 97 of which have an additional day. [KALENDAR.] The Julian year, in use before the Gregorian reformation, is a portion of a cycle of 4 years of 365 days, one of which has an additional day. Without a perfect comprehension of the manner in which the incommensurability of the year and day is remedied, no progress can be made in the understanding of the nature and use of chronological periods.

An Æra means either the commencement of an indefinite reckoning, or of a succession of periods. In the article ÆRA will be found the complete description of the most important æras; but as it often happens that for reference the mere time of an obscure or uncommon æra is wanted without explanation, we subjoin an extensive list, merely giving the leading words, and the date A.D. or B.C. of the vulgar Christian æra. It is to be remembered that the birth of Jesus Christ is supposed to have taken place in the fourth year B.C. of this common æra. The figures following the years refer to months and days: thus A.D. 729 . 6 . 13 would stand for[*] the 13th day of June, A.D. 729. We do not mean to say that the events in the following list did take place in the years, far less in the months, or on the days, which are set down: but only that those who used them as æras, took them as having happened in those years, months, and days. Thus the death of Alexander, according to Clinton, took place in B.C. 323, which is most likely to be right; but if those who afterwards made an æra of this death, reckoned from the 12th of November B.C. 324, that day is the æra, whether the event happened then or not.

Mundane æra of Constantinople	B.C. 5508 . 3 . 21 (or 4 . 1)
Civil æra of Constantinople	B.C. 5508 . 9 . 1
Mundane æra of Alexandria	B.C. 5502 . 8 . 29
Mundane æra of Antioch	B.C. 5492 . 9 . 1
Commencement of Julian period	B.C. 4713 . 1 . 1
Common mundane æra (Abp. Usher)	B.C. 4004
Mundane æra of the Jews	B.C. 3761 (vernal equinox)
Civil Jewish æra	B.C. 3761 . 10 . 1
Caliyug (Hindu)	B.C. 3101
Æra of Abraham (Eusebius)	B.C. 2015 . 10 . 1
Olympiads	B.C. 776 . 7 . 1
Building of Rome (Varro)	B.C. 753 . 4 . 21
Building of Rome (Cato)	B.C. 752 . 4 . 21
Æra of Nabonassar (Babylonian)	B.C. 747 . 2 . 26
Metonic cycle	B.C. 432 . 7 . 15
Calippic period	B.C. 330
Julian reformation	B.C. 45
Death of Alexander	B.C. 324 . 11 . 12
Æra of the Seleucidæ	B.C. 312 . 9 . 1
Æra of Tyre	B.C. 125 . 10 . 19
Æra of Vicramiditya (Hindu)	B.C. 57
Cæsarean æra of Antioch { Greeks	B.C. 49
Cæsarean æra of Antioch { Syrians	B.C. 48
Spanish æra	B.C. 38 . 1 . 1
Æra of Actium	B.C. 30 . 1 . 1
First leap-year of the Augustan reformation	A.D. 8
Æra of the Ascension (as used in the Chronicle of Alexandria)	A.D. 38
Æra of Salivahan (Hindu)	A.D. 77
Æra of Diocletian, or of Martyrs	A.D. 284 . 9 . 17
Indiction of Constantinople	A.D. 312 . 9 . 1
Æra of the Armenians	A.D. 552 . 7 . 9
Hegira	A.D. 622 . 7 . 16
Æra of Yezdegird	A.D. 632 . 6 . 16
Gregorian reformation, or new style	A.D. 1582
English adoption of the Gregorian reformation	A.D. 1752

Among the various sources of confusion may be noticed—1, an old practice of astronomers, who call the year immediately preceding and following the vulgar æra, not 1 but 0, as calculation requires; 2, the discrepancies arising from different times of beginning the year. The most important of these to the English reader is the following: Before the change of style in 1752, and from the 14th century to that time, the legal and ecclesiastical year began on the 25th of March, though it was very common in writings, &c., to begin it on the 1st of January. Hence January, February, and twenty-four days of March, were in one year, according to lawyers, &c.; and in another according to others. Thus the Revolution, so called, of 1688, took place in the February of that legal year, or, as we should now say, February, 1689. It is frequently written thus: February, $168\frac{8}{9}$, or February, 1688-9. Thus, King Charles was beheaded January 30, $164\frac{8}{9}$, or January 30, 1648-9.

We now come to the artificial periods which are of most use in chronological researches: these are—

1. The cycle of the sun, or more properly the cycle of Sundays.
2. The cycle of the moon, or of nineteen years, or of the Golden number, or of the Primes, or the Metonic cycle with its æra altered. [METON, in BIOG. DIV.]
3. The cycle of indictions.
4. The Paschal cycle.
5. The Julian period.

1. The cycle of the sun is a period of 28 years, compounded of 7 and 4, the number of days in a week, and the number of years in the interval of two leap-years. This, *in the old style*, makes the Sundays return to the same days of the year; every year of the cycle being in this respect exactly the same as the same year of the preceding cycle. Thus, the year A.D. 1 being the tenth in its solar cycle, and the DOMINICAL LETTER being for that year B, or the 2nd of January being Sunday, the 2nd of January was also Sunday in the year A.D. (1 + 28), or A.D. 29, also in A.D. (29 + 28), or A.D. 57, &c.

The series of dominical letters for the complete solar cycle is as follows: attached to each dominical letter is what is called the *concurrent* of the year, meaning the number of days elapsed over and above a complete number of weeks, from the beginning of the cycle (not including the first day) to that of the year in question, the concurrent being written 7 where 0 would perhaps have been better.

1	GF	1	8	E	2	15	C	4	22	A	6
2	E	2	9	DC	4	16	B	5	23	G	7
3	D	3	10	B	5	17	AG	7	24	F	1
4	C	4	11	A	6	18	F	1	25	ED	3
5	BA	6	12	G	7	19	E	2	26	C	4
6	G	7	13	FE	2	20	D	3	27	B	5
7	F	1	14	D	3	21	CB	5	28	A	6

Connected with this table is one of what were called solar *regulars* (regulators would have been the modern term), one for each month, as follows:—

Jan.	2	April	1	July	1	Oct.	2
Feb.	5	May	3	Aug.	4	Nov.	5
March	5	June	6	Sept.	7	Dec.	7

The table given in DOMINICAL LETTER would save some of the following process, which however it is better to give.

Old Style.—To find the part of the solar cycle in which any given year is found. If the year be A.D., add 9 and divide by 28; the remainder (or 28 if the remainder be 0) is the year of the solar cycle required. But for a year B.C., deduct 10 from the date, and divide by 28; the remainder deducted from 28 gives the year. The dominical letter and concurrent are then taken from the preceding table. And to find on what day of the week the first day of any month fell, to the concurrent of the year add the regular of the month, the sum (diminished by 7, if it can be done) shows the day, 1 being Sunday, 2 Monday, &c. (But in leap-year one day later must be taken for every month after February.) Thus to find the day on which the æra of the Hegira fell, or July 16, 622 A.D., 622 + 9 or 631 divided by 28 gives the remainder 15, which is the year of the cycle. The concurrent is 4, which added to the regular of July 1, gives 5, or Thursday for the 1st July, and Friday for the 16th; whence Friday is the day required.

The perpetuity of the solar cycle, in the connection of its numbers with the dominical letters, &c., is destroyed by the new style, in which a similar cycle of no less than 2800 years exists. Up to the end of this century, however, the cycle of 28 years, as it now exists, will remain undisturbed,[*] and it may therefore be worth while to give the years of the solar cycle answering to the decads of the century, and the table of dominical letters, concurrents, and regulars :—

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[*] There is some incorrectness, but great convenience in this. Astronomers now sometimes use such a notation as 1859·61, not to denote 1859 years *and* 61-100ths of a year, but the moment at which 61-100ths of the 1859th year have elapsed.

[*] Since A.D. 1900 is not leap-year, the whole cycle will then be overthrown, but since A.D. 2000 is leap-year, it may be reconstructed so as to last till 2100.

1801, 18	1820, 9	1840, 1	1860, 21	1880, 13
1810, 27	1830, 19	1850, 11	1870, 3	1890, 23

1	ED	1	8	C	2	15	A	4	22	F	6
2	C	2	9	BA	4	16	G	5	23	E	7
3	B	3	10	G	5	17	FE	7	24	D	1
4	A	4	11	F	6	18	D	1	25	CB	3
5	GF	6	12	E	7	19	C	2	26	A	4
6	E	7	13	DC	2	20	B	3	27	G	5
7	D	1	14	B	3	21	AG	5	28	F	6

Jan.	3	April	2	July	2	Oct.	3
Feb.	6	May	4	Aug.	5	Nov.	6
March	6	June	7	Sept.	1	Dec.	1

To find the 1st of April, 1836 : the year is 25 of the cycle, and leap-year, and the concurrent 3 added to 2, the regular of April, with 1 allowed for leap-year, gives 6, or Friday.

There are many *perpetual almanacs*, as they are called, by which such questions as the preceding can be solved by reference, without calculation. But when the almanac of a particular year is wanted in totality, there must be thirty-five distinct almanacs set out, to meet every possible location of Easter-day, with an index by which the year is to show which almanac to turn up. Several of the monastic orders constructed almanacs for themselves on this principle, with their own peculiar days of ceremony duly entered : and M. Francœur published a general one at Paris in 1842. On this hint Mr. De Morgan constructed his 'Book of Almanacs,' 1851, in which the *whole almanac* of any year, the moon * excepted, is turned up at once, whether in old or new style.

2. The cycle of the moon is that of 19 years, which is very nearly 235 complete lunations, as follows : the 235 mean lunations of 29·53059 days each make 6939·69 days, while 19 years of 365 days each give 6935 days, and, allowing 4¾ days for leap-years, 6939·75 days. Hence 235 lunations fall short of 19 Julian years by ·06 of a day, or one day in about 317 years. During a period of 300 years, and as far as the mean place of the moon is concerned [Easter], the new and full moons of the cycle of nineteen years would fall on the same days. On the assumption of 235 lunations exactly corresponding to 19 years, all the rules for finding Easter are founded; and in the steadiness with which this false assumption was held to, lies the value of Easter in chronology. If the astronomers had been allowed to vary Easter according to the latest improvements in determining the moon's place, the chronology of the details of the different years of the middle ages, confused as it sometimes is, would rarely have been anything but confusion; in chronological reckoning nothing is of any importance compared with keeping to one unvaried rule; and the reformation (so called) of the calendar was, in our opinion, anything but an improvement.

Chronologists have two cycles of nineteen years each, the first of which is the cycle of nineteen years (so called), or of the golden number, and the second, which begins three years later, they call the lunar cycle. These of course only differ in their time of commencement, the year 4 of the first cycle being always 1 of the second. To show the manner in which accuracy was attempted, it is worth while to quote the date of one charter, from the 'Art de vérifier les Dates,' particularly as all the dates are quite exact : "Acta sunt hæc, anno ab incarnatione Domini MCIX., indictione II., epacta XVII., concurrente IV., cyclus lunaris V., cyclus decemnovennalis VIII., regularis paschæ IV., terminus paschalis XIIII. kal. Maii, dies paschalis VII. kal. Maii, lunæ ipsius (diei paschæ) XXI."

After what has been said on Easter, there is no occasion to enter on that subject here.

The epact of the year is usually stated as being the moon's age at the beginning of the year : this is a correct definition as to the epact of the Gregorian calendar, but not so as to that which preceded. The epact of the old calendar is a number depending on the year in such manner that the epact of the year, increased by what was called the lunar regular of any month, gives (with deduction of 29, if necessary) the age of the moon on the first day of that month; so that the age of the moon at the beginning of the year is the epact, together with the regular of January. Thus the epact of every year may be increased or diminished at pleasure, provided all the numbers in the table of regulars be as much diminished or increased; and different tables of epacts will be found in different works, the difference being of course compensated in the regulars, or else in the rule for applying them. The epact of each year of the cycle of 19 years must be 11 more than that of the preceding, abating 30 as fast as it arises; this must be the case in every table, and the most common table of epacts gives 29 as the epact of the first year of the cycle, 10 as that of the second, 21 as that of the third, &c. Corresponding to this, 9 is the regular of January, 10 of February, &c. It is not worth while to give the table, not only because it is now useless, even for old chronology, but because it fails for those years of the decemnovennal cycle in which two full moons come in the same month.

Again, the annual regular, or the regular cited in charters (as in our previous quotation, where it is called the paschal regular), is neither the solar regular described in the former part of this article, nor the lunar regular just mentioned, but a third regular belonging to the whole year, and which, added to the concurrent previously described, gave (7 being abated, if necessary) the last day of the moon preceding the paschal moon. Thus, A.D. 874, the concurrent being 4 and the annual regular 5, their sum 9 diminished by 7, or 2, gives Monday as the last day of the ante-paschal moon.

The paschal term (terminus paschalis) mentioned in the quotation, meant simply the fourteenth day of the paschal moon.

3. The Indiction was an edict of the Roman emperors, fixing the tribute; and as one such edict was supposed to have appeared every fifteen years, years were naturally reckoned according to their distance from the year of indiction. There is doubt about the first origin of indictions, about their meaning and their earliest date : all we have here to do with is the fact, that from Athanasius downwards, they were more or less employed by ecclesiastical writers in describing epochs. The popes afterwards adopted this mode of dating, and the common indiction * found in chronological tables begins so that A.D. 313 is the first year of the first cycle of indiction, each cycle containing 15 years. At this rate, A.D. 1 was the fourth year of an imaginary preceding indiction, and the remainder of three more than the date of any year divided by 15 will give its position in its cycle of indiction. Thus 1239, increased by 3 and divided by 15, gives the remainder 12, or A.D. 1239 is the twelfth year of a cycle of indiction.

4. The paschal cycle is one composed of 28 and 19 years, or 532 years, during which time the cycles of the sun and of 19 years run through all their combinations, and recommence them again. According to the old system, then, this is the cycle of Easter Days, which begin again in the same order when it is finished: A.D. 1 was the second year of the first paschal cycle, being also 2 of the cycle of 19 years, and 10 of its solar cycle. The paschal cycle of the Gregorian calendar would be 53,200 years.

5. The Julian † period was imagined by Joseph Scaliger, and is a combination of the solar cycle, the cycle of 19 years, and that of indictions. Now 28 × 19 × 15 gives 7980 years, which is the length of the period in question. It was made to begin at a year B.C., which was the first year of each cycle—namely, B.C. 4713 years. Hence, subtract any year B.C. from 4714, or add any year A.D. to 4713, and you have the year of the Julian period answering to the date used. The advantage (if it be one) of this period is, that by dividing the year in it by 28, 19, and 15, the remainders show the years of the different cycles belonging to the Julian date used, remembering when the remainder is nothing to substitute the divisor instead.

For the history of periods not absolutely used in chronology, see their several names, such as Metonic Cycle, under Meton, in Biog. Div., Saros, Sothiac Period, &c., &c.

Astronomical periods, actually existing in nature, may be divided into *days*, connected with the rotations of planets round their axes; *months*, connected with the rotation of satellites round their primaries; *years*, connected with the rotations of primary planets round the sun; and *secular* periods, connected with slow changes of the elements of orbits. The most convenient period of measurement is the civil or mean solar day at the earth, being the average interval between noon and noon. [Synodic Revolution.]

This period being divided into hours, &c., the actual rotation of the earth is $23^h\ 56^m\ 4^s{\cdot}09$, and is called the sidereal day. The average interval between two transits of the moon over the meridian is $24^h\ 50^m\ 28^s{\cdot}32$, which might be called the mean tide-day. The rotation of the moon is the time of her revolution round the earth [Moon]; and the rotations of the planets are as follows (in *sidereal* time) so as to make 24^h the rotation of the earth :—

	d.	h.	m.		h.	m.
Sun . .	25	8		Jupiter . . .	9	56
Mercury . .		24	5½	Saturn . . .	10	29½
Venus . .		23	21	Uranus unknown.		
Earth . .		24		Neptune unknown.		
Mars . .		24	38			

Various months are described in the article Moon, the only ones here necessary to cite being the one already used, of $29^d\ 12^h\ 44^m\ 2^s{\cdot}9$, or $29^d{\cdot}53059$, the average interval from new moon to new moon, and

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* Means are added of finding the new or full moons of any year, within a day, without any calculation : and also means of calculation to find them within two hours.

* The first indiction of Constantine is variously stated to have been A.D. 312, 313, 314, and 315.

† Some say that the name was in honour of his father, Julius Scaliger; some that it was called from the Julian year. The discrepancy need never have arisen, for Joseph Scaliger says, "Julianam vocavimus quia ad annum Julianum accommodata." ('De emend. temp.,' ed. 1629, Geneve, p. 361.) The false account was probably fostered by the great honour in which Joseph Scaliger held his father, whose son he frequently called himself in his title-pages. But this name referred to a very different person. The treatise just quoted first appeared in 1583, just after the reformation of the calendar : and Scaliger was a warm opponent of Clavius in this matter. He stood up for the old Julian year. In the very first mention of the period which occurs (Preface, p. ii.), he says, "Qui anno Juliano, quæ omnium formarum temporibus est convenientissima, uti volet, is . . . . componet elegantissimam periodum annorum 7980, . . ."

27^{d} 7^{h} 43^{m} 11^{s}·5, or 27^{d}·32166, the actual time of revolution of the moon in the heavens. The satellites of Jupiter, Saturn, and Uranus have revolutions round their primaries as follows:—

		d.	h.	m.		d.
Jupiter's	First S. . . .	1	18	28	or	1·7691
	Second S. . . .	3	13	14		3·5518
	Third S. . . .	7	3	43		7·1546
	Fourth S. . . .	16	16	32		16·6888
Saturn's	Ring . . .	0	10	32		0·4370
	First S. . . .	0	22	38		0·9427
	Second S. . .	1	8	53		1·3702
	Third S. . . .	1	21	18		1·8878
	Fourth S. . .	2	17	45		2·7395
	Fifth S. . . .	4	12	25		4·5175
	Sixth S. . . .	15	22	41		15·9453
	Seventh* S. . .	21	7	8		21·2972
	Eighth S. . .	79	7	55		79·3296

The following are the old statements relative to the satellites of Uranus, as given by William Herschel. Such an article as this is not the place to enter upon the doubts relative to these bodies.

		d.	h.	m.	d.
Uranus's	First S. . . .	5	21	25	5·8926
	Second S. . .	8	16	58	8·7068
	Third S. . . .	10	23	4	10·9611
	Fourth S. . .	13	10	56	13·4559
	Fifth S. . . .	38	1	48	38·0750
	Sixth S. . .	107	16	40	107·6944
Neptune's	Satellite . . .	5	21	3	5·8769

The civil year is the *tropical* year, or the time of revolution of the sun from the vernal equinox to the same again. Owing to the motion of the equinox [PRECESSION], this year, or 365^{d} 5^{h} 48^{m} 49^{s}·7, or 365^{d}·2422414, is shorter than the actual revolution of the earth round the sun, which is 365^{d} 6^{h} 9^{m} 9^{s}·6, or 365^{d}·2563612. Again, the *anomalistic* year, being that in which the earth moves from its nearest point to the sun to the same again, is 365^{d} 6^{h} 13^{m} 49^{s}·3, or 365^{d}·2595981. The following is the list of the actual revolutions of the planets round the sun, each to a tenth of a day, including the verified periodic comets, so far as their times are known:—

	Days.		Days.
Mercury . .	88·0	De Vico's Comet .	1993·0
Venus . . .	224·7	Brorsen's Comet .	2042·0
Earth . . .	365·3	Biela's Comet .	2394·0
Mars . . .	687·0	Faye's Comet . .	2718·0
Encke's Comet .	1210·0	Jupiter . .	4332·6
Vesta . . .	1325·7	Saturn . . .	10759·2
Juno . . .	1592·7	Uranus . .	30686·8
Ceres . . .	1681·4	Halley's Comet	75 to 76 years.
Pallas . . .	1686·5		

Of secular periods, the most important are, the revolution of the moon's node, in 18·6 years; of the earth's perihelion, from the vernal equinox to the vernal equinox again (the latter also moving), or 21,000 years, and the revolution of the equinoxes themselves, in 26,000 years.

PERIŒCI (περίοικοι), an old astronomical term for those who have the same latitude, but opposite longitudes.

PERIPATETICS (περιπατητικοί) is the name given to an ancient philosophical sect. It was so designated from the circumstance of its founder, Aristotle, being accustomed to deliver his doctrines while walking in the grove of the Lyceum in the suburbs of Athens. [ARISTOTLE, in BIOG. DIV.] There is scarcely any department of human knowledge of which the writings of Aristotle do not treat. It would far exceed the limits of this article to give a full detail of his opinions. Such of them only as characterised the school which he originated can be referred to, and even these must be briefly noticed. They have relation chiefly to his general physical and metaphysical principles. To his system of logic, with the additions subsequently made to it by his disciples, it is unnecessary particularly to advert. [ORGANON.]

Previous to Aristotle's time it was commonly supposed by those who had speculated respecting the origin of the universe, that there is an eternal substance from which bodies are made, and on which forms are impressed, and to which the name of matter was assigned. This matter was understood to have been always in motion, to consist of indefinitely small particles, and to have been collected and united in bodies by the agency of an intelligent principle. It was further supposed that the original particles had certain properties by which they differed from each other, and by which the constitution of the bodies which they composed was determined. Empedocles and others taught that there were four primary elements, which are the bases of all corporeal forms; Anaxagoras and his followers maintained that bodies exactly represent the form of each of their constituent particles: while Plato held that essential forms have an actual existence in the divinity, and that by the union of these with matter the formation of bodies is effected.

Rejecting all these theories, Aristotle assumed the underived and independent existence of two opposite principles. But since such principles by their contrariety would destroy each other, the existence of a third was requisite. These he conceived to be matter, form, and privation, the first two being the constituent principles of things, and the last being accidentally connected with them. The first matter was imagined to be entirely destitute of all qualities, to exist potentially, and to be the subject in which forms are made to inhere. Form he explained to be the essence of a thing, or that which constitutes it what it is. How the first matter and form were brought into union so as to produce bodies does not appear; unless nature, the meaning of which term, as employed by Aristotle, it is not easy to apprehend, accomplishes the union.

Aristotle distinguished causes into the material, the formal, the efficient, and the final; the first being that of which things are made, the second that by which they are what they are, the third that by the agency of which anything is produced, and the last the design of its production. Having thus provided for the existence of substances generally, Aristotle divides them into three classes: the eternal, as the heavens; the perishable, as the bodies of animals; and the immutable nature, or prime mover, as it was otherwise called. This prime mover, which occupies the place of God in his system, was considered to be an eternal, incorporeal, and simple intelligence, and the original source of all motion, being itself unmoved. Its agency extended directly to the first celestial sphere, and mediately through similar inferior intelligences to the lower spheres, and by them to the universe at large.

Sensible bodies were divided by Aristotle into simple and compound; simple bodies being those elements which result from the combination of primary matter and form, and compound bodies those which proceed from elementary combinations. In bodies thus distinguished there are certain active and passive qualities, which constitute their specific difference, and by which they mutually tend to transform each other into their own nature. In consequence of the action of the first mover, whether direct or indirect, on matter, there is a continual succession of dissolution and reproduction; reproduction taking place when the essence of a body is entirely changed, and only an augmentation or diminution when its accidental qualities undergo mutation.

Such is an imperfect sketch of Aristotle's general doctrine of physics. His opinions respecting man may be shortly summed up. The principles of the soul and of animal life he thought to be identical, giving them the common designation of entelecheia (ἐντελεχεια), or perfect energy. The faculties of the soul he considered to be, the nutritive, by which life is produced and preserved; the sensitive, by which we perceive and feel; and the rational, by which we understand. The sensitive faculty takes cognisance of external objects by means of its organs, which are adapted to produce the various sensations of sight, hearing, &c. The senses receive forms or sensible species in the same manner as wax receives the impression of a seal. Fancy is the perception which results from the immediate operation of the senses; while memory is derived from fancy, and is the effect of images formed in the soul by the senses. The intellectual or rational faculty is of two kinds, either active or passive. Passive intellect receives the form of things, and is the seat of species. Active intellect is either simple or complex: simple when it engages in the close apprehension of its object; complex when it combines simple conceptions so as to engender belief. Intellectual action is theoretical when it contemplates what is simply true or false, and practical when it determines what is good or evil, and thus gives rise to volitions.

Whether Aristotle believed in the immortality of the soul or not, has not been clearly ascertained. From his notion that the soul is a power externally transmitted into the body, it has been inferred that he held it to be mortal, and that it ceased to have a separate existence after the dissolution of the body.

Aristotle's school in the Lyceum was continued for about twelve years. In consequence of the hostility of his enemies, who accused him of propagating impious tenets, he retired, soon after the death of Alexander, to Chalcis, where he died. Before withdrawing from his public labours however he appointed Theophrastus, of Eresus in Lesbos, his successor in the chair. The opinions of Theophrastus differed in some respects from those of Aristotle, but he taught with great success, and was attended by about two thousand scholars. He was followed consecutively by Straton of Lampsacus, Lycon, or Glycon of Troas, Ariston of Ceos, and Critolaus the Lycian. With Diodorus of Tyre, who came immediately after Critolaus, the uninterrupted succession of the Peripatetic school terminated, about the 140th Olympiad. Among the early followers of the Stagirite, who did not fill the chair, were several eminent philosophers. The most distinguished of these were Dicæarchus, a Messenian, Eudemus of Rhodes, and Demetrius Phalereus.

The Peripatetic doctrines were introduced into Rome in common with the other branches of the Greek philosophy by the embassy of Critolaus, Carneades, and Diogenes, but were little known till the time of Sylla. Tyrannion, an eminent grammarian, and Andronicus Rhodius, were the first who brought the writings of Aristotle and Theophrastus into notice. The obscurity of Aristotle's writings tended much to hinder the success of his philosophy, but it nevertheless soon gained a considerable number of supporters. During the reign of the Cæsars, it acquired all its ancient influence; and till the time of Ammonius, the preceptor of Plutarch; was taught with great purity. After that it was divided into two sects, consisting respectively of those who wished to adhere strictly to Aristotle, and those who were disposed to amalgamate his doctrines with those of other schools. Julius Cæsar and Augustus patronised the Peripatetic philosophy. Under Tiberius, Caligula, and Claudius, its adherents, in common with those of other sects, were either banished or obliged to remain silent on the subject of their peculiar tenets. This was the case also during the greater part of the reign of Nero, although during the early part of it philosophy was favoured. The chief Peripatetics in the first century of the Roman empire were Sosigenes of Egypt, who wrote a commentary on Aristotle's treatise 'De Cœlo,' Boethus of Sidon, who is mentioned by Strabo as having been his fellow-student in the Aristotelian philosophy, and Nicolaus of Damascus in Syria.

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* Discovered in 1848 by Lassell and Bond.

Ammonius the Peripatetic made great exertions to extend the authority of Aristotle; but about his time the Platonists began to study his writings, and prepared the way for the establishment of the Eclectic Peripatetics under Ammonius Saccas, who flourished about a century subsequent to Ammonius the Peripatetic. Even after this period however some were still found who adhered exclusively to Aristotle. The most celebrated of these was Alexander of Aphrodisias, who was a public professor of the Peripatetic philosophy, under Septimius Severus, in Alexandria or in Athens. Many of the Eclectic Aristotelians wrote commentaries on his works, some of which are still extant. The principal of these writers were Themistius, who flourished during the reigns of Constantius and Theodosius the Great; Olympiodorus, who lived about a century later: and Simplicius Cilix, in the time of the emperor Justinian.

After this period, philosophy in general languished. But in that mixture of ancient opinions with theological dogmas which constituted the philosophy of the middle age, the system of Aristotle undoubtedly predominated. About the 12th century it had many adherents among the Saracens and Jews, particularly in Spain; and at the same period also it began to be diligently studied, though not without much opposition, among the ecclesiastics of the Christian church. Out of this latter circumstance gradually arose the Scholastic philosophy, which took its tone and complexion from the writings of Aristotle, and which continued long to perplex the minds of men with its frivolous though subtile speculations. The authority of Aristotle received a severe shock at the Reformation, but it survived the fall of the Scholastic system. His opinions were patronised by the Roman Catholic church, on account of their supposed favourable bearing on certain doctrines of faith; and although Luther and others of the Reformers determinedly opposed them, they were maintained by such men as Melancthon, who himself commented on certain portions of the works of the Stagirite. Many individuals distinguished for their genius and learning exerted themselves to revive the Peripatetic philosophy in its primitive purity, nor did it cease to have numerous illustrious supporters until the time of Bacon, Grotius, and Des Cartes.

PERI'PHERY, the Greek word for circumference; term applied both to rectilinear and curvilinear figures.

PERIPNEUMONY. [Lungs, Diseases of the.]

PERIPTERAL or PERIPTEROS. [Temple.]

PERI'SCII (whose shadows move round). In those latitudes which are high enough to have the sun for twenty-four hours together, the shadows make complete revolutions; whence the inhabitants may be called Periscii (Περίσκιοι).

PERISCOPIC SPECTACLES. [Spectacles.]

PERITONITIS is an inflammation of the peritoneum. It may exist either as an acute or as a chronic disease. The chief symptoms of the acute form are pain, swelling, and tenderness of the abdomen, accompanied with fever and a frequent, small, and hard pulse. The pain in peritonitis is usually much more severe than that of any other inflammatory disease of the intestines or other abdominal organs. It is acute and cutting, and sometimes occurs in paroxysms; it is generally diffused, but occasionally it is almost confined to a single part of the abdomen; but its most distinguishing character is that it is greatly increased by pressure, so that in a severe case the patient cannot support so much as the weight of the bed-clothes, but lies on his back with his knees drawn up, and breathes quickly and lightly, moving the diaphragm as little as possible, so as to avoid the pain which its pressure would excite in the inflamed parts. The bowels in cases of peritonitis are usually, but by no means constantly, constipated; commonly also there are present nausea, vomiting, and hiccup, and almost always excessive thirst and prostration of strength. If not checked in its course, acute peritonitis usually terminates fatally in from five to ten days; the patient becoming more and more depressed, and all the symptoms regularly increasing till within a short time of death, when the pain commonly ceases, and a deceptive improvement in many of the other signs of the disease takes place.

The usual morbid effects of peritonitis are the effusion of serum with lymph or pus into the cavity of the abdomen, and adhesions of the opposite surfaces of the several organs within it. After death from acute peritonitis, the walls of the abdomen and the surfaces of the organs chiefly or alone affected, are found thickened, swollen, and vascular, covered with blotches of dilated blood-vessels, and more or less firmly adhering together by the lymph which is effused between them, and which, if the patient survives for a certain length of time, becomes vascular, and is converted into the usual tissue of adhesions or false membranes. [Inflammation.]

The causes of peritonitis are various. Like other acute inflammations, it may occur after exposure to cold, or the other common excitants of disease; but it is more certainly produced by injuries of the peritoneum, as by tumours developed within the abdomen, by the obstructions which occur in strangulated hernia, and intussusception, of which it is a constant consequence, by the spreading of disease from the adjacent viscera, by heavy blows and falls on the abdomen, by penetrating wounds inflicted in operations for hernia or in other circumstances, by the passage of foreign bodies into the cavity of the abdomen, and especially by the ulcerative perforation or accidental rupture of any of the organs contained within it, and the escape of their contents, circumstances which are productive of the most certainly and rapidly fatal form of the disease.

From these causes acute peritonitis may occur at all periods of life, but it more frequently affects persons of the middle age than any others. Women in child-bed are peculiarly liable to it. They may be attacked either with common peritonitis, presenting no remarkably peculiar symptoms or effects; or they may have that which is especially called puerperal peritonitis. In cases of the latter disease, however, the peritonitis is not always the most important symptom, but must rather be regarded merely as one of the coincidents of the peculiar fever by which the patient is affected, and which often assumes the character of an epidemic.

The treatment of peritonitis may commence with local bleeding by the application of leeches to the abdomen. General bleeding may be had recourse to where the symptoms are severe and the patient's strength will bear it. Hot fomentations should be assiduously applied to the abdomen. Of internal medicines the most effectual is calomel, of which three or four doses of five grains or more, with one or two grains of opium, should be given at intervals of about four hours, and afterwards smaller doses till a slight salivation is produced. During all the time of the treatment, the lowest diet only should be allowed, unless the patient is evidently sinking. In that case, and generally in the later stages of the disease, a more nutritious diet may be given, but there is perhaps no affection in which relapses are so liable to occur in consequence of the early or injudicious use of stimulating food.

Acute peritonitis sometimes, after fifteen or twenty days' continuance, assumes a chronic form. Sometimes peritonitis from its commencement is of slow progress; the pain being but slight or discoverable only by considerable pressure, and the swelling or tension of the abdomen occurring only at a late period of the disease. Its more important symptoms are the low fever, the constant thirst, the hectic flushings of the face, the emaciation, languor, and regularly increasing debility by which it is accompanied. It rarely proves fatal till after many months have elapsed; and its effects are found after death to be thickening and increased density of all the peritoneal coverings, increased vascularity or blackness of their surfaces, which in many cases are beset with vast numbers of minute grayish-white tubercles, and effusions of serum with lymph or pus wherever the adjacent organs are not connected together by the adhesions. The chronic form of disease is always the result of a scrofulous state of the body and is seldom cured. The treatment of chronic peritonitis is usually unsatisfactory and of doubtful benefit. Local bleedings should be employed, and blisters or other counter-irritants should be applied over the abdomen. The diet should be light and nutritious, and, as often as they seem necessary, mild purgatives may be administered. Frictions of ointments containing mercury or iodine are also useful, and iodine should be administered internally when the patient is of a scrofulous constitution.

PERJURY, by the common law of England, is the offence of falsely swearing to facts in a judicial proceeding. To constitute this offence the party must have been lawfully sworn to speak the truth by some court, judge, or officer, having authority to administer an oath; and, under the oath so administered, he must wilfully assert a falsehood in a judicial proceeding respecting some fact material to the subject of inquiry in that proceeding. In a legal sense therefore the term has a much narrower import than it has in its popular acceptation. It is said by Sir Edward Coke (3 'Inst.,' 166) that "the deposition must be direct and absolute, and not *ut putat*, nor *sicut meminit*, nor *ut credit*," &c.; but this doctrine has been long since exploded; and it is now clear that a person may commit perjury by swearing that he *believes* a fact to be true which he *knows* to be false. It is immaterial, with reference to the offence of perjury, whether the false statement has received credit or not, or whether any injury has been sustained by an individual in consequence of it. The characteristic of this offence therefore, by the law of England, is not the violation of the religious sanction of an oath, nor the wrong done to the person or property of another, but the injury done to the administration of justice by false testimony or information in a judicial proceeding.

The history of perjury at common law is entirely dependent upon the history of the trial by jury. Where it is mentioned by Bracton and Fleta, these ancient authors allude exclusively to the offence of jurors in giving a wilfully false verdict; and as the jury appear to have been originally merely witnesses, speaking from their personal knowledge of the facts, and sworn to *speak the truth*, their misconduct in giving a false decision might be justly treated as perjury. As population and civilisation increased, the nature of the trial by jury became changed, and witnesses were called in order to inform the jurors respecting facts of which the latter were commonly ignorant, though the institution was originally founded upon the presumption that they must necessarily be acquainted with them. It is probable that this alteration did not take place at once, but that it was one of those gradual introductions by means of which laws silently adapt themselves to changes in national habits and circumstances. At all events, there is no trace in the statutes or in the reported proceedings of the courts, of any penal law against perjury in witnesses, as distinguished from that of jurors, earlier than the reign of Henry VIII. The date of the introduction of the witness's oath to speak the truth, in use at the present day, is unknown, and no form of process for securing the attendance of witnesses (except where they were added to the jury) seems to have existed before the reign of Elizabeth. These facts tend to show that the offence of perjury has been gradually moulded into its present definite character, by the corresponding change in the functions of the jury. This change however was complete in the time of Sir Edward Coke, as he defines perjury nearly in the same terms in which it is described in the modern textbooks. (3 'Inst.,' 163.)

A defendant in equity is guilty of perjury by false swearing in his answer to a plaintiff's bill. He is in fact also a witness, for he is bound to answer on oath to the matter contained in the bill, and the plaintiff may read the whole or any integral portion of the answer as evidence against him. In the case of an answer in equity, the offence of false swearing falls exactly within the definition given above.

The punishments of perjury by the common law were, fine and imprisonment, and the pillory, which latter punishment was abolished in 1837. To these was added an incident probably derived from the punishment of jurors in ancient times, namely, a perpetual incapacity to give evidence in courts of justice. A statute of Geo. II. allowed imprisonment with hard labour for seven years, or transportation for a like period, to be imposed as the punishment for this offence; the effect of recent enactments has been that perjury is now punishable by imprisonment, with or without hard labour, or penal servitude for that term.

Subornation of perjury consists in wilfully procuring any person to commit perjury; and it is essential to this offence that the false oath should be actually taken. The same punishment is assigned to subornation as to perjury.

Besides perjury and subornation of perjury at common law, the statute 5 Eliz., c. 9, contains a legislative enactment respecting these offences; but as this enactment is more limited than the common law, both in the definition of the crime itself and in the punishment to be applied to it, it has seldom been founded upon in recent times; and within the last century there have been few if any instances of prosecutions under this statute. There are also many statutes by which oaths are required as a sanction to statements of facts under a variety of circumstances, and otherwise than in judicial proceedings; and these statutes frequently declare that false swearing in such cases shall amount to perjury, and be punishable as such.

In those cases in which a solemn declaration may be taken in lieu of an oath [OATH], the offence of making the declaration falsely is the same as perjury, and punishable in like manner.

PERMANGANIC ACID. [MANGANESE.]

PERMUTATIONS. [COMBINATIONS.]

PERNAMBUCO-WOOD, COLOURING MATTER OF. [BRAZIL-WOOD, COLOURING MATTER OF.]

PERPENDICULAR (overhanging), the name given in geometry to a line or plane which meets another line or plane without inclining to one side or the other, so as to appear to proceed directly towards the other line or plane. The subject will be considered in a mathematical point of view under RIGHT ANGLE.

PERPETUAL MOTION. [MOTION.]

PERPETUATION OF TESTIMONY. A party who has an interest in property, but not such an interest as enables him immediately to prosecute his claim, or a party who is in possession of property and fears that his right may at some future time be disputed, is entitled to examine witnesses in order to preserve that testimony, which may be lost by the death of such witnesses before he can prosecute his claim, or before he is called on to defend his right. This is effected by such party filing a bill in equity against such persons as are interested in disputing his claim, in which bill he prays that the testimony of his witnesses may be perpetuated. This is the only relief that the bill prays. If the prayer of the bill is granted, the evidence of the witnesses will be taken in the usual way. The depositions, when taken, are sealed up and retained in the custody of the court. When they are required to be used as evidence, they can be so used, by permission of the court, by the party who has filed his bill or those who claim under him, and they can be read by the direction of the court as evidence on a trial at law, if it is then proved that the witnesses are dead, or from any sufficient cause cannot attend. If the witnesses are living when the trial takes place, and can attend, they must be produced. A defendant to such a bill may cross-examine the witnesses and he is entitled to use their depositions as evidence in his favour at a future trial. (1 'Mer.,' 434.)

A bill to perpetuate testimony may be filed by any person who has a vested interest, however small, in that thing to which he lays claim. The parties, defendants to such bill, are those who have adverse interest to the plaintiff. In order that the testimony which the plaintiff seeks to perpetuate may be good evidence for him at the trial, he must make all proper parties defendants to his bill, who may be generally described to be such persons as would be necessary parties to a bill in equity by the plaintiff to enforce or maintain his rights, if a court of equity could take cognisance of the matter, and the question between the plaintiff and such parties could then be raised. The evidence so taken may be read at the hearing of a cause, or at a trial at common law against all such parties to the bill, and those who claim through or under them. The act 5 & 6 Vict., c. 69, entitled "an act for perpetuating testimony in certain cases" makes no change in the procedure of the courts in suits of this kind.

A bill to perpetuate testimony must not be confounded with the practice of examining witnesses De bene esse. The bill to perpetuate testimony has been already described. The examination of witnesses De bene esse is only resorted to when an action has been brought, and the plaintiff is afraid that his witnesses, owing to age or infirmity, may die before the trial can take place, or he has only one witness to an important fact. Both these are in a sense proceedings to preserve or perpetuate testimony; but the one is applicable before the matter which may be in dispute can be the subject of judicial investigation, and the other when an action has been already brought. But under the reformed practice of the courts of chancery and common law a bill to examine witnesses De bene esse appears to be no longer necessary.

Witnesses may be examined De bene esse in a suit in equity, when it is necessary to secure their evidence at a period of the suit prior to the regular time for examination of witnesses in the cause. But this is only a provisional examination, and the evidence can only be used in case the witnesses cannot be examined at the proper time for the examination of witnesses in the cause. The value of the practice is much diminished in consequence of changes in modern practice, by the operation of which the length of time between the institution of a suit and its coming to the issue is greatly abridged. (Daniel's 'Ch. Pract.,' 3rd ed., p. 736.)

PERPETUITY, the technical term for a yearly payment or annuity which is to continue for ever; also called a perpetual annuity.

PERPETUITY (Law). [SETTLEMENT.]

PERSÉPHONE (Περσεφόνη), or PERSEPHONEIA (Περσεφόνεια), called by the Romans PROSERPINA, was the daughter of Zeus and Demeter. (Hesiod. 'Theog.' 913.) She was carried off by Pluto while gathering flowers in the Nysian plain (Homer, 'Hymn in Demet.,' 17), and made the queen of the regions of the dead. Demeter, inconsolable for the loss of her daughter, afflicted the world with sterility; till at length Zeus consented to the return of Persephone to her mother; but as she had eaten food in the regions below, she was obliged to spend one third of the year with Pluto, and was allowed to pass the other two-thirds with Demeter. The tale of the rape of Persephone is related at length in the Homeric Hymn to Demeter, and by Ovid and Claudian. The last two writers state that Proserpina was gathering flowers near the city of Enna in Sicily, when she was carried off by Pluto. In Homer, Persephone is mentioned as the goddess of Hades ('Od.,' xi. 217); but her rape by Pluto is not mentioned either in the 'Iliad' or 'Odyssey.'

Persephone is frequently called Kora (Κόρη), that is, the 'Maiden,' by the Attic writers. This goddess and her mother Demeter were also worshipped under the name of the 'Great Goddesses' (*αἱ μεγάλαι θεαί*, Pausan., viii. 31, § 1.) [DEMETER.]

Representations of Persephone are very numerous in Greek art. The most common in pure Greek sculpture are in connection with her mother; several are mentioned under Demeter. Later she is perhaps most commonly represented as being carried off by Pluto: this was a very favourite type on Græco-Roman sarcophagi, referring to the grief caused by the untimely or unexpected carrying away of a beloved one by Death. Sometimes Persephone is seen enthroned beside Pluto. She appears as a younger Demeter, but is of a graver and more severe countenance: the Hera of the lower regions.

PERSEPOLITAN ARCHITECTURE. [PERSIAN ARCHITECTURE.]

PERSEUS (constellation). The mythological story of Perseus is well known: in the heavens the constellation is surrounded by Andromeda, Aries, Taurus, Auriga, Camelopardalus, and Cassiopeia. Of the two principal stars α and β (the latter of which is called Algol), the former is situated in the breast of the figure, the latter in the head of Medusa, which he carries in his left hand. The following are the principal stars:—

Character.	No. in Catalogue of Flamsteed.	No. in Catalogue of British Association.	Magnitude.
(ρ^1)	16	871	4
γ	23	947	3
e	25	953	4

Character.	No. in Catalogue of Flamsteed.	No. in Catalogue of British Association.	Magnitude.
β	25	963	2⅓
α	33	1043	2½
δ	39	1129	3
ν	41	1138	4
ζ	44	1207	3
ε	45	1219	3
μ	51	1287	4
	(123)		4
	(253)		4
θ	13	827	4

PERSIAN ARCHITECTURE. Looking at the scanty and imperfect remains of the architecture of ancient Persia, architects and archæologists were unable to trace in them the evidence of a wholly independent style, yet found many difficulties in reconciling their characteristics with those of the buildings of ancient Egypt, the only known architecture to which that of Persia bore any marked resemblance. The remarkable discoveries of MM. Botta and Layard have, however, shown pretty decisively what had indeed been suspected before (Müller, 'Handb. der Archäologie,' § 242), that Persian architecture was really an imitation or development of that of Assyria. [Nineveh, Architecture of.] The sculptured slabs of ancient Nineveh, the human-headed bulls, the bull-headed capitals, and even many particularities in the arrangement, are seen to have been reproduced at Persepolis and Susa. Persepolis the capital, and Pasargadæ the dwelling-place and the grave of the kings of ancient Persia, were contemporary with the later days of Babylon the mighty, and in all of them the same peculiar cuneiform inscriptions are found. [Cuneiform.]

For the origin of Persian architecture we need not therefore look farther. The remains of the two kinds are, however, very different. The exhumed buildings of Assyria are essentially palaces. What have been examined of ancient Persia seem to consist chiefly of temples, or temple-palaces, and tombs.

The most extensive and remarkable ruins occur on the site or in the vicinity of Persepolis, the ancient capital. They consist of a series of separate grand halls, probably intended for public receptions and religious ceremonies, in which the monarch took part. One of these halls has been called the palace of Darius, another that of Xerxes, and there are traces of several others; but including all of these the plan would have been exceedingly limited, and inadequate to the accommodation required for the court of an eastern prince and a numerous retinue, unless the buildings originally extended much beyond the actual ruins. Probably, as has been suggested, the actual residences of the family, court, and dependents of the king, were detached buildings, which, being "composed of inferior materials, have been washed away, or they dwelt in the neighbouring palace in the town of Istakr, or in some of the buildings on the plain which are now in ruins." (Fergusson).

The present inhabitants call the chief ruin in Persepolis Tak-Jamschid, or the residence of Jamschid (supposed by them to have been its founder); recent authorities regard it as the hall or palace of Xerxes. By the Mohammedans it is called Tchil-Minar, or the Forty Columns, of which number, however, scarcely half are now remaining. The ruins stand upon an artificial eminence formed of admirably built marble masonry. This height consists of three terraces, and extends upwards of 400 yards from north to south, and about 300 from east to west. Though it may be described as a parallelogram in its general shape, this platform is not perfectly regular in plan, being indented by projections and recesses, which follow the sinuosities of the superficies of the rock itself; neither is it one uniform level throughout, those parts which were covered with buildings being somewhat elevated above the rest. The height above the plain from which the rock rises varies considerably in different places, in some being not more than 14 feet, and in others 40. On every side except the east, where it adjoins a hill forming a lofty screen or background to it, the platform is enclosed by walls or parapets constructed of large blocks of masonry. As that opposite the loftier ground to the east, the west side (1425 feet in extent), may be considered the principal one or front, and accordingly here we find the entrance, not, however, in the centre, but about midway between that and the north-west angle. The ground is here somewhat more than 20 feet below the terrace, owing to which there is a considerable ascent. This gave the architect an opportunity of which he availed himself, to make the entrance by a grand staircase which formed a principal feature in the composition. Instead of being formed by wide flights of steps in a direct line leading to the entrance, it consists of two separate ramps or flights in contrary directions, which return again to the upper landing-place. The lower staircases are of large unadorned courses of masonry: the upper flights are profusely ornamented with sculptured relievi. Facing the upper landing-place, but at some little distance from it, is a *propylon*, or lofty mass forming a doorway, somewhat similar to those in Egyptian architecture, and a little beyond it a second entrance of the same kind, which, as Mr. Fergusson believes, was the opposite entrance to the same pile, which was in fact a distyle hall, having its roof supported by four pillars,—probably one of those Gates of Justice common throughout the east, and of which mention is frequent in the Old Testament. Like the Egyptian, these propyla diminish upwards, and are crowned by a cavetto, or hollow cornice: they are also adorned with fanciful colossal figures of animals, partly in low and partly in high relief, sculptured on their sides,—a human-headed winged bull being sculptured on each of the jambs of the first entrance almost identical in character with those found in the palaces at Nineveh and Khorsabad; whilst at the opposite entrance are bulls without wings. Other but smaller halls are on either side. On the right of this is the grand hall, the approach to which is by another double flight of stairs, the sides of which are lined by treble rows of bassi-relievi slabs, with figures of processions, &c., like those found at Nineveh. The principal mass of building now remaining lies on the south or right hand of the entrance just described, and extends westward. This structure contains within, not a spacious hall suited for entertainments, but one filled with lines of columns, six in each line, so as to form a number of aisles intersecting each other. Such a grove-like arrangement of numerous pillars is altogether unlike anything in Grecian architecture, but a similar disposition of pillars prevailed among the Egyptians, as may be seen in the plan of the temple at Edfu [Egyptian Architecture], where both the pronaos and vestibule are in the same manner *polystylar*, or filled with columns, although they occupy a smaller space, and are consequently not so numerous. A more remarkable example is the temple of Karnak, described in the same article. In front, and flanking each side of the great hall, are hexastyle porticoes, the columns being two deep.

There are on the platform several halls or buildings, some appearing to have had four, others sixteen, thirty-two, and one a hundred pillars. This last was a decastyle hall of, as would seem, about 225 feet each way, but as its entire height (according to Mr. Fergusson) was barely 25 feet, it was of low proportions. It had a portico in front flanked by two colossal bulls, on pedestals 18 feet long and 5 feet high; and the flanks of the doorway were sculptured with representations of the king on his throne, and of various mythological subjects; but it had no lateral porticoes, and was altogether inferior in magnificence to the hall of Xerxes.

From a careful comparison of the remains at Persepolis and Susa with those of Assyria and the representations of a Persian palace on the tomb of Darius at Naksh-i-Rustam, Mr. Fergusson conjectures ('Palaces of Nineveh and Persepolis Restored') that two orders of pillars were employed to support the roofs of the palace of Xerxes, one with double bull capitals, the other with the Ionic volutes such as are seen in the columns of the northern portico and generally in interiors. Brackets of wood he thinks supported the beams of the roof, at least internally, the double bull capital surmounting the Ionic scrolls on the outside. The palace, he thinks, "supported a raised platform or *talar*, on its roof; identical with that represented in the tomb (of Darius at Nakah-i-Rustam) on which the fire-altar was placed at which the king used to worship, or on which he was wont to exhibit himself to his subjects on state occasions." On the whole, Mr. Fergusson states as the result of his studies of Assyrian and Persian architecture in general, and of this building in particular, that "presuming it be sculptured and painted as richly as other buildings of its age and class, which it no doubt was, it was not only one of the largest, but one of the most splendid buildings of antiquity. In plan it was a rectangle of about 300 feet by 350, and consequently covering 105,000 square feet; it was thus larger than the hypostyle hall at Karnac, or any of the largest temples of Greece or Rome. It is larger, too, than any mediæval cathedral except that of Milan; and although it has neither the stone roof of a cathedral, nor the massiveness of an Egyptian building, still its size and proportions, combined with lightness, and the beauty of its decorations, must have made it one of the most beautiful buildings ever erected, and both in design and proportion far surpassing those of Assyria, though possessing much of detail or ornament so similar as to be almost identical in style." ('Handbook of Arch.' i. 197.) Of the splendour of the building there can be no question, but of its surpassing beauty we must take leave to doubt.

The taller columns at Persepolis are of gray marble, 5 feet 9 inches in diameter, and 65 feet 8 inches in height; while the shorter; or those with the Ionic scroll, are 40 feet to the bottom of the capital, that, including the Ionic scroll, being 16½ feet: they are therefore of very slender proportions. Of some of these columns the shafts are ornamented with a kind of zigzag or vandyke pattern, after the manner of the fragment found near the Treasury of Atreus at Mycenæ; while others are fluted, but the channels are exceedingly narrow, being forty, or double the number of those of a Doric column. The bases and capitals are still more singular, both of them being very deep and of fanciful shape and outline. The most remarkable are formed by placing two bulls' heads and fore-parts back to back. Those with Ionic volutes have the volutes set vertically instead of horizontally. Mr. Fergusson has given restored copies of the bull-headed columns, and those with Ionic volutes, from Persepolis and Susa in his building called the Assyrian Court at the Crystal Palace, Sydenham.

At Pasargadæ there are vast artificial platforms, and extensive ruins; but none sufficiently uninjured to permit of their identification with any particular edifice, or even to determine to what kind of building they belong. The great platform about 300 feet square, and nearly 40 feet high, is formed of 14 courses of large blocks of white marble, each stone being beautifully fitted and clamped to its neighbour, and bevilled at the joints,—it is therefore admirable as an example of ancient Persian masonry, but of little architectural value. Other marble platforms occur on which also buildings have once doubtless stood, but of which no vestiges remain. In the plain are a fragment or two of large isolated pillars; and a curious tower-like structure of white marble 9 feet square, and 49 feet high. This is probably one of the fire-temples of the ancient Persians. A similar building is found at Istakr opposite the tombs of Naksh-i-Rustam. It is of marble; and the lower part being solid, it is entered by a door some height from the ground. There is a small square upper chamber, the roof of which is formed by large slabs of stone; and this roof is said to still show marks of fire.

At Susa, Mr. Loftus discovered, in 1843, the foundations of a temple-palace almost identical in plan with the Great Hall of Xerxes at Persepolis, and which though more ruinous than that building, has served to complete our knowledge of the portions there wanting. Many fragments of bases and capitals, like those of Persepolis, but rather richer in detail, were also found among the ruins of Susa. Inscriptions on the bases of the columns record the names of Darius and Xerxes as the builders, and Artaxerxes Memnon as the restorer of the edifice. Other names also occur. This may have been, as has been suggested, the very hall of Shushan, described in the book of Esther; and at any rate the account there given (c. i. v. 6) of the splendour of the fittings, the columns of marble, and the coloured marble pavement, on which were beds or thrones of gold and silver, will serve to indicate the magnificence of the hall when in its pristine glory.

At Naksh-i-Rustam are several tombs and sepulchral chambers hewn out of the perpendicular face of rocks. For the most part these excavations are very shallow, and consist chiefly of an architectural frontispiece or portico richly adorned with sculpture and other decorations. The most remarkable is the Tomb of Darius, the son of Hystaspes, at the foot of Mount Rachmed, near the river Bendemir, the ancient Araxes. This monument has a portico of four columns, whose capitals have figures of the foreparts of animals projecting from their sides. There are also two rows of sculpture above the portico, with a figure of the king above standing opposite a fire-altar, and over all a winged deity is seen floating in the air. As already mentioned, the whole frontispiece of this tomb appears to be intended to represent the royal palace: an excellent engraving of it is given in Coste and Flandin's 'Perse Ancienne.' The only example of a constructed tomb occurs at Pasargadæ, where a small temple stands on the summit of a low pyramid of stone steps, around which, but at some little distance, is traceable a peristyle or colonnade: this is ascertained from the descriptions in Greek writers to be the Tomb of Cyrus.

(Sir R. K. Porter, *Travels*, vol. i.; Chardin, Morin, &c., *Travels*; Hirt, *Baukunst*; Flandin and Coste, *Perse Ancienne*; Fergusson, *Palaces of Nineveh and Persepolis Restored*; *Handbook of Architecture*.)

PERSICA. [PEACH.]

PERSONAL ACTIONS. [ACTIONS.]

PERSONALTY AND PERSONAL PROPERTY. [CHATTELS.]

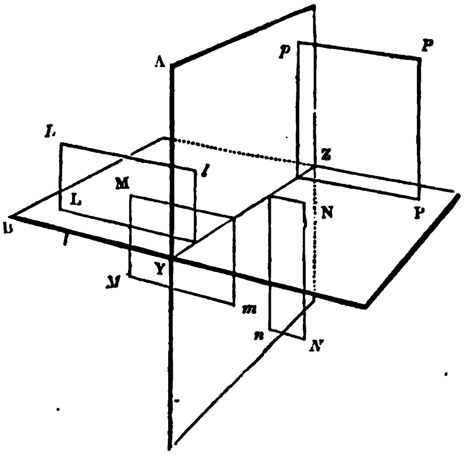
PERSPECTIVE, a term popularly given to an application of geometrical principles, by means of which a *pictorial* outline of a certain class of objects may be delineated on a plane surface. Thus understood it has been defined to be the art of representing on a plane surface the outlines of objects in the same forms, positions, and relative proportions which they bear to each other in nature as seen from a given point. A perspective representation corresponds in fact to a section of a cone of rays, the apex of which is in the eye of the observer (62, 64). In other words, if a pane of glass were interposed between us and any object or objects which we were viewing through a small hole (or *sight*), and we were to trace on the glass an accurate outline of the objects as they appeared on it, that outline would be a perspective representation: and it is the purpose of the art of perspective to show how this may be done if the necessary data be furnished. Perspective constitutes however only a specific case of a more general application of the geometrical principles above alluded to, which enable us to make constructions relating to geometrical *solids*, bearing the same relation to geometry of three dimensions that practical bears to theoretical plane geometry. In the present article these principles will be explained, and their application to perspective be shown (66 *et seq*),—specifically with reference to geometrical solids, but capable of extension to the objects delineated in pictorial representations.

The analyst, in his investigations of symbolical expressions for the relations of geometrical magnitudes, refers these, according to the species of magnitudes under consideration, either to co-ordinate lines on a plane, or to co-ordinate planes, assumed at pleasure in space. [CO-ORDINATES.] The draughtsman, or practical geometrician, makes his constructions on the lines and figures themselves, when they lie wholly in one plane; and when he has to make constructions on geometrical solids, he is compelled to refer the various points, lines, and figures connected with or constituting those solids to one or more planes, to effect his object; and from constructions on these planes he can determine the unknown quantities of the original solids by means of their *projections*, as they are termed, knowing the conditions under which these projections were obtained.

1. The series of points of any geometrical solid are most simply supposed to be referred to a plane by parallel right lines, passing through them perpendicular to the plane; the intersections of these lines with the plane are termed the *projections* of the original points on that plane.

2. Let us conventionally designate the original points by Italic capital letters, and their projections by small letters; thus *P* means a point in space, *p* its projection on a plane.

3. The points *l*, *m*, *n*, on a plane A Y Z, are therefore understood as referring to the points in space, situated in right lines passing through *l*, *m*, *n* respectively, perpendicular to that plane; but these projections alone do not define the relations between the original points; for *l*, *m*, *n* are each the projections of an infinite number of original points, of all in short through which each *projecting line* may pass. To define the specific points *L*, *M*, *N*, we must consequently not only have *l*, *m*, *n*, but the lengths respectively of the projecting lines *Ll*, *Mm*, *Nn*, or the distances at which *L*, *M*, *N* are respectively situated from their projections.



4. This second series of essential data is furnished by the projections L, M, N of the original points on a second co-ordinate plane B Y Z, perpendicular to the first, and therefore parallel to the former projecting lines, by which *l*, *m*, *n* were determined; while, conversely, the first plane must be parallel to the projecting lines by which L, M, N are determined. For if a third plane be conceived to pass through the two projecting lines *L*L, *Ll*, of any point *L*, and therefore necessarily perpendicular to the two co-ordinate planes, the intersections of this third plane with the two latter will, together with the two projecting lines themselves, form a rectangle; consequently the distance of any projection L, from the common intersection Y Z of the co-ordinate planes, is equal to the length of the *projecting line Ll*, which is parallel to it; while, conversely, the distance of the other projection *l* of the same point *L* from the same common intersection is equal to the length of the *projecting line L* L.

5. Let us designate the third plane just described as the *projecting plane* of an original point. It follows as a corollary from this definition of the plane, that the *projecting planes* of a series of points L, M, N are parallel to each other, and perpendicular to both co-ordinate planes, as well therefore as to the common intersection Y Z of those co-ordinate planes.

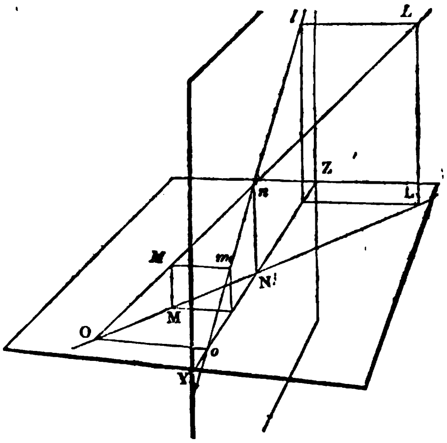
6. Let Y Z always designate the common intersection of the two co-ordinate planes; let the projections L, M, N be termed the *plans*, and the projections *l*, *m*, *n* the *elevations* of the original points *L*, *M*, *N*. It follows that if an original point lie in either co-ordinate plane, its projecting line will coincide with that plane, and its projection on the other will be a point in Y Z.

7. Let us next consider a right line *LM*, supposed to join or pass through two points in space *L*, *M*. Then the right line L M joining or passing through the *plans* of *L* and *M*, is called the *plan* of *LM*, and *lm* is the *elevation* of the same original line.

8. It is obvious, from the preceding definitions, that the *plan* and *elevation* of any original right line *LM* in space are the intersections with the co-ordinate planes respectively of two planes passing through the original line perpendicular to the co-ordinate planes.

9. We will distinguish the projecting plane of an original line *LM*, by which the *plan* of that line may be conceived as produced, as the *plan-projecting plane* of *LM*; and the projecting plane by which *lm* is produced, as the *elevation-projecting plane*. But the reader must not confound the *projecting plane* of an original point, which is necessarily perpendicular to both co-ordinate planes, with the *projecting plane* of an original line; which, though necessarily perpendicular to one co-ordinate plane, may be parallel, perpendicular, or oblique to the other, according as the original line is parallel, perpendicular, or oblique to that other co-ordinate plane. Nevertheless the projecting plane of an original line will always intersect that co-ordinate plane, to

which it is not necessarily perpendicular, in a line which is perpendicular to Y Z.



10. Besides the plan and elevation, there are two other elements regarding an original line which it is necessary to consider; these are the points in which that line itself intersects the two co-ordinate planes. The principles of projection furnish us with the following theorems relating to these points, and to the plan and elevation of the line.

11. If the original line be parallel to both co-ordinate planes, it can intersect neither, and both its plan and elevation are parallel to Y Z. It is clear, on this supposition, that the original line is itself also parallel to Y Z.

12. If the original line be perpendicular to one, and therefore parallel to the other co-ordinate plane, the projection on that other plane will be parallel to the original, and perpendicular to Y Z, while the projection on the first will be a point, that in which the original line itself intersects that co-ordinate plane.

13. If the original line be oblique to one, and yet parallel to the other co-ordinate plane, its projection on that to which the line is *not* parallel will be parallel to Y Z; while its projection on the co-ordinate plane, to which the original is parallel, will cut X Z in the projection of the point in which the original intersects the former co-ordinate plane.

14. If the original line be oblique to both co-ordinate planes, neither its plan nor elevation can be parallel to Y Z; the plan of the line will cut Y Z in the projection of the point of intersection of the original with the co-ordinate plane in which its elevation lies; while that elevation will cut Y Z in the projection of the intersection of the original with the plane in which the plan lies.

15. It also follows that the projecting line of the point in which an original line intersects either co-ordinate plane coincides with the intersection of the projecting plane of that line.

16. If an original line, oblique to both co-ordinate planes, lie in a plane perpendicular to them both, its plan and elevation will both be perpendicular to Y Z, since its two projecting planes will coincide with that in which the line lies. In this case the plan and elevation could not furnish sufficient data for determining the original lines, since they would be common to every line, in the perpendicular plane, which was not parallel to either plane of projection; if however we have, in addition to the indefinite plan and elevation of the line, those of two points in it, or the two points in which the original line cuts the two co-ordinate planes, then the original line is determined.

17. Let us next consider in what manner an original plane may be conceived to be referred to two co-ordinate planes. It is clear that as only one plane can be drawn through a straight line and a point, or, which is the same thing, through the two legs of a plane angle, the plans and elevations of any two lines through which the plane passes will determine it. But the intersections of the original plane with the two co-ordinate planes furnish a datum regarding it of more direct application.

18. The intersections of an original plane with the co-ordinate planes are termed its *traces*.

19. The traces of a plane on either co-ordinate plane will obviously pass through the points in which two or more lines lying in the original plane intersect that co-ordinate plane.

20. If an original plane be parallel to one co-ordinate plane, its trace on the other will be parallel to Y Z.

21. If an original plane be perpendicular to either co-ordinate plane, its trace on the other will be perpendicular to Y Z, at the point in which the trace on the first plane meets that line; and the plane oblique angle formed by the trace and Y Z will be the measure of the dihedral angle formed by the original with the other co-ordinate planes. If an original plane be perpendicular to a co-ordinate plane, its trace on that plane will be the common projection of all lines in the original plane, and will pass through the projection of all points in that original plane.

22. If the original plane be parallel to Y Z, its traces on the co-ordinate planes will both be parallel to Y Z, and therefore to each other; but in every other case, if the original be oblique to both, or meet both co-ordinate planes, its traces on them must intersect in a point of Y Z. And if the plane be perpendicular to both co-ordinate planes, both its traces will be perpendicular to Y Z.

23. If two original lines are parallel, the plans of those lines will be parallel, as will also be their elevations; but the plans or the elevations only of two lines may be parallel, although the lines themselves are not so, the parallelism of either the plans or elevations simply arising from the accidental parallelism of the plan or elevation projecting planes of the original lines.

24. An analogous theorem applies to two original planes: if these be parallel, their traces on both co-ordinate planes will be parallel; but if their traces are parallel on one plane only, it simply indicates that the original planes intersect each other in a line parallel to that co-ordinate plane.

25. The planes of two lines may cut one another, as may also the two elevations, and yet the originals may not lie in one plane, and therefore cannot meet each other. If two original lines really intersect, the points in which the plans and elevations cut each other must lie in the projecting plane of the point in which the originals meet.

26. The projections of equal parallel lines will be equal parallels, in the ratio to the originals of the cosine of the angle in which those originals are inclined to the plane of projection, to radius. If two lines forming an angle be parallel to two others, whether lying in the same or different planes, the projections of each two lines will form equal angles.

27. The plane angles, which are the projections of equal angles, will be equal, provided the original angles are similarly placed with respect to the traces of the planes in which those originals lie; or else when the original angles lie in a plane parallel to either co-ordinate plane, and then the projected angles must be equal to the originals.

28. Hence, since the projection of every parallelogram is a parallelogram (23), the angles of the projection corresponding to the adjacent angles of the original figure will also be complementary to each other.

29. If an original plane and line be mutually perpendicular, the projection of the line will be perpendicular to the trace of the plane on each co-ordinate plane. For since the projecting plane of the line must, on this supposition, be perpendicular both to the original and to the co-ordinate plane, and consequently so to their common intersection, which common intersection is the trace of the plane, this projecting plane will cut the co-ordinate plane in a line, namely the projection of the original, perpendicular to the trace of the plane.

30. If a line in an original plane be parallel to a co-ordinate plane, the projection of that line will be parallel to the trace of the plane; and conversely, if the projection of a line situated in a plane be parallel to the trace of that plane, the original line is parallel to the co-ordinate plane in which that trace lies.

31. These theorems on projections would be useless to the practical geometrician so long as the co-ordinate planes are supposed to retain their relative situation in space; to enable him to make the requisite constructions on the projections, and to determine the unknown magnitudes entering into the original solids by means of the projections of the known ones, he supposes the one co-ordinate plane turned round on the common intersection Y Z till the two planes coincide in one and the same plane: by this supposition the relations to Y Z of the lines, points, and traces, on the plane which is supposed to be turned round, remain unaltered; while the principles on which the projections are made allow of the correct interpretation of the new relations which the projections of original points and lines on one plane assume with regard to the projections of the same points and lines on the other plane, when these two co-ordinate planes are supposed to coincide in one.

32. The same method of bringing two planes into one may be applied, or rather conceived to be applied, to the *projecting plane* of any original point or line, this projecting plane being supposed turned round on the projection of the line till the plane coincide with the co-ordinate plane, that is to say, a construction can be made with the projection of a line founded on this supposition, by which a line may be found representing the original line as brought into the co-ordinate plane; and by an analogous construction, an original plane may be constructed as if turned round on its trace till it coincide with the co-ordinate plane.

33. This principle may be carried still farther: thus a construction can be made, founded on the supposition that an original plane has been turned round on its intersection with another such plane till they coincide, and this compounded plane, if we may use such an expression, has been again turned round on its trace till it has been brought into the common plane of projection.

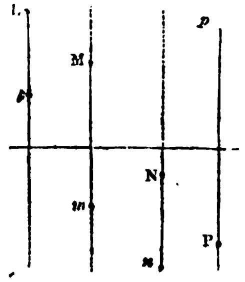
34. It must hence be understood that the practical application of the theory of projections is entirely synthetical, that is, the draughtsman, first drawing a line to represent Y Z, proceeds from this simple assumption to draw the projections of certain points and lines of a solid, on which he proposes to operate, from their known, assumed, or

given relations to each other, and from their conventional relations to the supposed co-ordinate planes, which may in every case be conceived to be so situated as to facilitate these constructions. Having thus got the projections of known or given lines, he proceeds from these data to ascertain the absolute magnitudes of lines and angles depending on these given ones, by making the constructions alluded to, founded on the supposition of projecting lines and planes being turned round on the projections determined by them, till they coincide with the co-ordinate planes.

35. If a plane be turned round on its intersection with another, a line in the former will make the same angle with that intersection, when the two planes are brought into one, that the line made with that intersection when the planes were in situ. The two lines which are the intersections of the projecting plane of a point (5) with the co-ordinate planes in situ, which lines have been shown to be equal respectively to the projecting lines (4) of that point, will be both perpendicular to Y Z, and therefore will coincide in one line perpendicular to that line Y Z, when the two co-ordinate planes coincide in one.

36. The two co-ordinate planes in situ form four dihedral angles, and an original point may be situated in any one of these; that is to say, of a system of related original points referred to those planes, some one or more may be in different dihedral angles: it is essential that the learner should know how to assign the relative situation of the original points in space from the relative situation of their plans and elevations to Y Z.

37. Let us distinguish the four dihedral angles thus:—

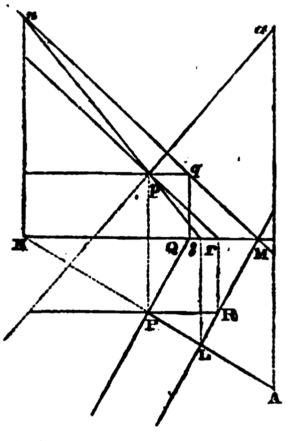


1. $+x+y$; the point P,p* is n the dihedral angle No. 1.
2. $-x+y$; „ L,l „ „ No. 2.
3. $-x-y$; „ M,m „ „ No. 3.
4. $+x-y$; „ N,n „ „ No. 4.

38. Our limits will only admit of two or three examples of elementary constructions to illustrate the subject of projections, referring to the theorem on which each step of the construction is founded.

Given a point P *p in a given line* A P, *ap, to draw a plane through* P,*p perpendicular to the given line.*†

39. Draw a line P Q through P, perpendicular to the plan of the line, for that of a line parallel to the co-ordinate plane, and lying in the plane sought; then (20) $p\,q$, parallel to Y Z, will be the elevation of this parallel. The line P Q, $p\,q$ meets the co-ordinate plane in Q, q (13) q therefore will be a point in one trace of the plane sought: and since this trace must be perpendicular to the elevation of the line, M n drawn through q perpendicular to $a\,p$ will be that trace. The same construction, applied, mutatis mutandis, to the other projection of the point, will furnish a point in the horizontal trace of the plane sought, which trace must be drawn through R perpendicular to A P. The two traces thus found will intersect each other in a point of Y Z (22).



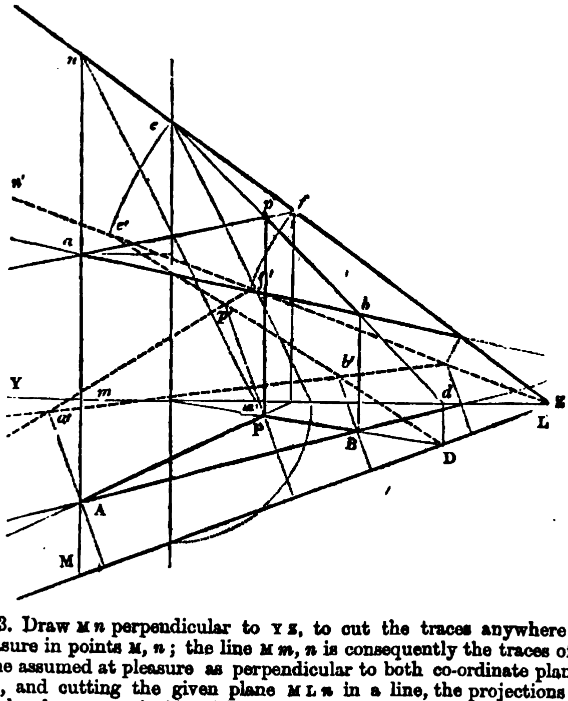
Given a plane L M, M *n, and a point* A,*a: to draw a line through the point perpendicular to the plane, and to determine the point in which this line cuts the given plane.*

40. Through A, a draw lines perpendicular to the given traces L M n for the indefinite projections of the perpendicular sought (29): from the point N, in which A N cuts Y Z, draw N n perpendicular to Y Z for the intersection with the other co-ordinate plane of the plan-projecting plane of the perpendicular (9); and from L, in which A P cuts M L, draw L l perpendicular to Y Z: the point l is the elevation of the point in which the plan-projecting plane of the perpendicular cuts the trace L M, M l; and n is that in which the same plane cuts the trace M n. Consequently $n\,l$ is the elevation of the intersection of the same plan-projecting plane with the original plane. Now it is obvious that the point sought must lie in this intersection; consequently the point p, in which $a\,p$ cuts $n\,l$, must be the elevation of the point in which the perpendicular intersects the given plane.

41. The plan P of the point may be obtained by drawing P p perpendicular to Y Z (35), to cut A N, the indefinite plan of the line; or by applying the foregoing construction, mutatis mutandis, to the other projections.

To draw a line through a given point P,*p, to make any proposed angle with a given line* A B, *a b.*

42. If the proposed line is to be *parallel* to the given one, lines drawn through the projections of the given point, parallel respectively to those of the given line, will be the projections of the line sought (23); but if the lines are not to be parallel, join P,p with any two points A, a, B, b, taken at pleasure in the given line. A B P will therefore be the plan, and $a\,b\,p$ the elevation of the triangle thus formed. Find the traces, M L, L n, of the plane of this triangle, by finding the points in which any two of its sides intersect the co-ordinate planes (19), since these points must lie in the traces required.*



43. Draw M n perpendicular to Y Z, to cut the traces anywhere at pleasure in points M, n; the line M m, n is consequently the traces of a plane assumed at pleasure as perpendicular to both co-ordinate planes (22), and cutting the given plane M L n in a line, the projections of which, of course, coincide with the traces of the plane. The length of this line, or the real distance between the points M n when in situ, is obtained by making $m\,m'$ in Y Z equal to m M; then the hypothenuse $m'\,n$ is the intersection of the given plane with the assumed plane, brought into the plane of projection by the rotation on $m\,n$ of this assumed plane.

44. From M and L, as centres, with $m'\,n$, L n for radii respectively,

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* 'The point P, p,' 'the line AB, ab,' 'the plane LM, Mn,' signify the point, line, or plane, the plans, elevations, or traces of which are A, a; AB, ab; LM, Mn, respectively.

† This is the form of enunciation of a prob. in solid geometry, and is to be thus interpreted: Given the projections P and p, on two co-ordinate planes supposed to be brought into one, of a point P situated in an original line of which the corresponding projections, A P, $a\,p$, are given; to draw the lines (traces) which will represent the intersections of a plane with those co-ordinate planes, this plane being supposed to pass through P, and to be perpendicular to $A\,P$.

* The sides of the triangle may meet the co-ordinate planes in different dihedral angles; the projections of two of these points, through which the same trace must pass, may therefore lie on contrary sides of Y Z. The traces of all planes should be drawn indefinitely extended on each side of this line Y Z, or are to be conceived as so extended when circumstances do not admit of their being shown so

describe arcs cutting in n'. Join M n', L n'; the triangle M L n' consequently (32) represents that portion of the given plane M L n intercepted between the co-ordinate planes and the line M m, $m\,n$, brought into the co-ordinate plane by being turned round on the trace M L, and by this rotation, bringing the original of the triangle, P A B, $p\,a\,b$, along with it. To draw this triangle as thus brought into the co-ordinate planes, produce P B, $p\,b$, to cut the two traces in D and e respectively, make L e' equal to L e, join D e'. In the same manner the lines $a'\,p'$ $a'\,b'$ are obtained, constituting the original triangle as brought into the co-ordinate plane in the manner described.

45. The points A a, B b, P p, lying in the original plane, will describe arcs of circles during the rotation of that plane on its trace: the planes of these circles must obviously be perpendicular to the original plane and to the co-ordinate plane, and consequently cut the co-ordinate plane in lines or traces perpendicular to M L, that of the original plane. Hence if lines be drawn through A, B, and P, perpendicular to M L, they will pass through a', b', and p', since the traces of these planes will be the projections of all lines lying in them, and therefore of the circular arcs alluded to (21), in which the points a', b', and p' lie. By this means the points a', b', and p' may be found, or verified if previously obtained on any other principle.

46. Draw $p'\,a'$ to make the proposed angle with a' b′[*]; then the plan A, and elevation of the point a', in which the proposed line meets the given one in the given angle, may be determined from a' by the converse proceeding to that by which a', b', and p' were obtained. And lastly, P A, $p\,a$ will be the projections of the line as required.

47. The foregoing construction might have been made with the trace L n instead of L M; but the triangle, when brought into the co-ordinate plane on the supposition of the rotation of the plane of that triangle on L n, would not coincide with $a'\,b'\,p'$.

48. If a line be conceived to move always perpendicular to a co-ordinate plane, and pass through an original curve, its intersection with the plane will be the projection of the curve; this projection being the section of the cylindroidal surface formed by the generating line. If the curve be any other than a circle or an ellipse, its projection can only be practically described by finding the projections of a sufficient number of points of the original, from some known property of the curve, or from the mode of its generation; and the required projection must be drawn by hand through the points thus determined. It is obvious that the projection of any plane curve which is parallel to the co-ordinate plane must be equal and similar to the original. But if the original curve be a circle, or an ellipse, the projecting line during its motion will generate a right or oblique cylindrical surface, the section of which by the co-ordinate plane must be either a circle or an ellipse.

49. Whatever may be the oblique position of an original circle with respect to the co-ordinate plane, there must be one diameter which is parallel to that plane; now the projection of this diameter being equal to the original, must be greater than those of all the other diameters of the original circle, which are all necessarily oblique to the plane: and since the projection of every diameter must be a diameter of the projected curve, the projection of this parallel one must be the major axis of the ellipse. This diameter of the original circle parallel to the co-ordinate plane is that which is parallel to the trace of the plane. The conjugate axis of the ellipse will be the projection of that diameter of the original circle which is perpendicular to the former, or to the trace of the plane.

50. The projection of a sphere on a co-ordinate plane must be a circle of the same radius as the sphere, this circle being the projection of that great circle of the solid which is parallel to the co-ordinate plane.

51. In the applications of practical geometry to the arts, the object is either to delineate the forms to which materials are to be reduced, or to guide workmen in making and putting together machinery; or, in the construction of edifices of every description.

52. Owing to the symmetry of the machines or edifices, the forms most commonly required to be delineated are reducible to series of rectangular geometrical solids, the planes of which are either parallel or perpendicular to the horizon. The plans, elevations, sections, profiles, &c., furnished to the workman by the draughtsman, are the projections on rectangular co-ordinate planes, assumed to be parallel to the planes of the machines or edifices, made to a reduced scale; the plan being such a projection, made on a horizontal plane, and the elevation on a vertical plane. When the building or engine is supposed to be laid open, by being cut by a plane, so as to show its interior, the projection made on this supposition is termed a section, or profile.

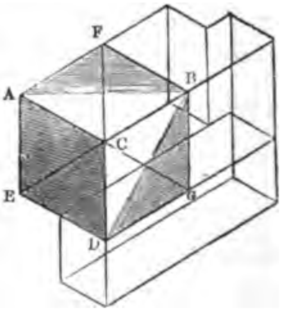
53. It is obvious, from these assumptions, that the various plane rectilinear, or mixed, figures which are produced by the intersections or boundaries of the various surfaces of the original objects, are represented on the draughtsman's plans, &c., by figures similar to the original forms; and that those plane surfaces of the original object which are vertical to the horizon appear only as right lines on a plan, bounding the figures which are the representatives of original planes parallel to the horizon; and, conversely, these last-mentioned surfaces are represented by lines in the elevations, while the vertical plane figures of the original are projected into similar plane figures on these elevations or profiles.

54. Hence two, at least, and commonly three, such projections, on rectangular co-ordinate planes, are requisite to convey an idea of the forms of an original object; but since these forms of the original are represented of their true dimensions and proportions, such projections are sufficient, and indispensable, as guides to the mechanics who are to construct or put together the edifice or machine.

55. The principles of projection enable us, as far as regards the rectangular parallelopiped, the solid of most frequent occurrence, to combine the two purposes for which such projections are employed; that is, to convey, by one image or figure, an accurate idea of the relative position of the parallel and vertical planes of an original object, reducible to this form, and at the same time to preserve one constant and correct proportion between the magnitudes of the original and of its representative.[*]

56. It has been shown (26, 27) that the projections of definite right lines, inclined in equal angles to the co-ordinate plane, will be in a constant proportion to the originals; if, therefore, the three plane right angles forming a solid angle of a rectangular parallelopided be inclined in equal dihedral angles to the co-ordinate plane, all lines parallel to the three edges of that solid angle will be projected into lines bearing one constant ratio to the originals, and forming with each other equal angles, which are the projections of the right ones formed by the original lines.

57. Thus, for example, if the co-ordinate plane be assumed perpendicular to the diagonal of a cube, the projections of the three edges meeting in either end of that diagonal will form angles of 120° with each other, and the three projections of the edges at one extremity will, respectively, bisect the equal angles formed by those of the edges at the other extremity; while the lines joining the ends of these six equal radii, which lines must obviously form a regular hexagon, will be the projections of the remaining edges of the solid. Each face of the cube is projected into an equilateral rhombus, as ACBF, BCDG, ACDE, BFCG, &c., the sides of which form angles respectively of 120° and of 60° each. If the side of the cube be unity, the equal projections of those sides will be ·8165, which is equal to the cosine of the angle at which the originals are inclined to the co-ordinate plane. The original diagonals of the three faces, AB, BD, DA, are obviously, from the symmetry and position of the solid, parallel to the co-ordinate plane; their projections are therefore equal to those originals, or are each equal to $\sqrt{2} = 1{\cdot}4142\ldots$ If an original solid be made up of rectangular parallelopipeds, having their faces mutually parallel, and the co-ordinate, or plane of projection, be assumed as equally inclined to the three faces forming any of the solid angles, the projections of all its edges, and of all lines parallel to them, would be in the constant ratio to the originals of ·8164 : 1; the dimensions, consequently, of those originals, as measured in the directions of lines which would be isometrically projected, may be set off from any scale along the isometric projections of any lines parallel to the edges of the original solids, and a figure or image of the original constructed which would show the three principal series of planes of which that original was composed.



58. The projections of all circles equally inclined to the co-ordinate plane will be similar ellipses; the axes of these ellipses, when representing circles lying in planes parallel to the faces of a cube equally inclined to the co-ordinate plane, will be to each other in the ratio of the diagonals of the rhombus representing the inscribed or circumscribing square isometrically projected. The following simple method of constructing a scale for determining the lengths of the axes of the isometric projection of a circle will be of service to the practical draughtsman. Construct a right-angled triangle the base and perpendicular of which are in the ratio of the side to the diagonal of a square, or as 1 : 1·4142. Set off the length of the isometric projection of the circumscribing square of any original circle along the side of this triangle, from the acute angle, and draw a line parallel to the other

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[*] In the figure, $p'\,a'$ is shown as the same line as the side of the assumed triangle, to avoid confusion; but this, obviously, need not be the case.

[*] This specific application of projection was termed *Isometric* by the late Professor Farish, who pointed out its practical utility, and the facility of its application to the delineation of engines, &c.: as a distinctive one, this term is unexceptionable.

side from the point thus marked off; this parallel, and the segment of the hypothenuse cut off by it, will be the minor and major axes of the ellipse. Since the major axis of the elliptic projection of a circle is always equal to the diameter of that circle (49), the major axis of the isometrical projection of a circle is equal to the side of the circumscribing square. Hence the axes of the ellipse and the side of the circumscribing square, when isometrically projected, are as $\surd 3 : \surd 1; \surd 2$.

59. The projecting lines and planes are assumed perpendicular to the rectangular co-ordinate planes, simply to facilitate the construction; but it is obvious that lines and figures may be projected on a plane by parallel projecting lines, making any angle with the plane of projection; such projections are termed *oblique*, but as they are but seldom employed, we shall only here give two general theorems relating to them; since we shall have occasion to recur to this subject in a subsequent part of this article. The oblique projection of a straight line, figure, or curve, lying wholly in a plane parallel to the co-ordinate plane, will be similar and equal to the original; and the oblique projections of parallel right lines will be parallels.

60. The oblique projection of a sphere must be an ellipse, for the parallel projecting lines which are tangential to the spherical surface must always form a right cylinder, the oblique section of which must be an ellipse. The major axis of this ellipse will be the intersection with the co-ordinate plane of one perpendicular to it, and passing through the oblique projecting line of the centre of the sphere. This major axis will consequently pass through the perpendicular, or ordinary projection of the centre of the sphere. The conjugate axis must clearly be equal to the diameter of the sphere.

61. We now proceed to show how, by a modification of the principles of projection, an image of an object, or a pictorial outline of it, may be obtained. It is however only to buildings, engines, machines, &c., consisting of strictly geometrical forms, that this modified projection can be applied; since the constructions by which these projections are obtained are as strictly geometrical as those by which we obtain the projections of such objects on co-ordinate planes.

62. Each point on the surface of an object is seen in the direction of a straight line,* supposed to be drawn from that point to the eye, and representing the reflected ray of light by which that point is rendered visible. The rays from every point of that surface will obviously form a geometrical solid pyramid, the surface of which will be composed of those rays which, touching the object, might be supposed prolonged in the same straight direction beyond it, without penetrating its surface. But when considering the subject of *outline* alone, we need only regard such of the internal rays of the pyramid as proceed from lines on the surface of the object, produced by the intersections of portions of that surface not continuous: and from our limitation of the class of objects, such lines must be either straight, or else geometrical curves; resulting from the mutual intersection of planes and curved surfaces with each other.

63. The general pyramid of rays will therefore be made up of a series of others, having one common vertex, and for their several bases the perimeter of a portion of continuous surface.

64. If we imagine these pyramids of rays cut by a plane, the common section will obviously be an outline of the object as it would present itself to an eye placed at the vertex, each line and point of the section coinciding with the corresponding line and point of the original.

65. As long as the object and the spectator's eye retain the same relative position, it is immaterial in what direction or at what distance the plane cuts the pyramids of rays; for the lines and points produced at each position of the plane must necessarily coincide with the originals when viewed from the vertex; although the outlines on the plane would vary for each of its positions. But each of these different outlines would suggest to the mind the same original combination of forms, provided it be viewed from the true vertex, and cannot be a correct representation or image of the object, if viewed from any other point.†

66. When we revert to the connection between this subject and drawing, in the common acceptation of the word, we shall point out the precautions that must be taken by the draughtsman, when applying the principles of projection to the pictorial delineation of objects, to prevent his drawing from appearing distorted when viewed indifferently from other than the correct point, which it must inevitably be on most occasions. But at present, dismissing all considerations of light, vision, and art, we shall proceed to treat this branch of the subject of projections, termed perspective, in a purely geometrical manner.

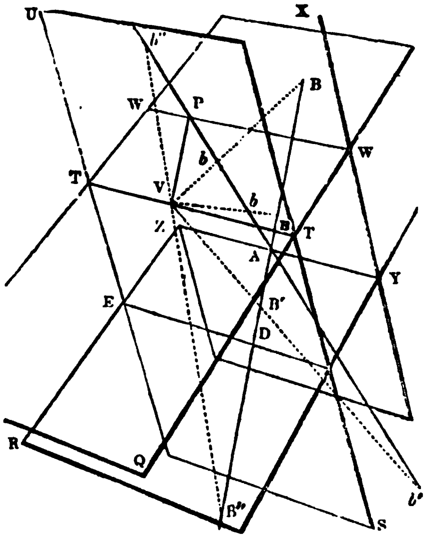
67. Instead of the simple elements alone, which entered into the constructions for determining lines and points, referred to a co-ordinate plane, by parallel lines perpendicular to that plane, we have in perspective projection the additional elements of the convergence of the projecting lines, or rays, intersecting the plane at different angles, depending conjointly on the distance of their point of convergence from the original lines, and from the plane. This variation in the conditions necessitates a different course of proceeding: in the former kind of projection the object of our constructions was to determine magnitudes; in that we are about to consider, our object is to delineate apparent and not real form.

68. The following definitions are here given to avoid unnecessary repetitions. The plane, on which the projection is supposed to be formed, and which is represented by the drawing board or paper on which the constructions are made, will always be termed *the plane of the picture.*

69. The point of convergence of the *rays*, or *projecting lines*, or the vertex of the pyramids of rays, will be designated as *the vertex.*

70. *The centre of the picture* is the point in which a line, through the vertex, perpendicular to the plane of the picture, meets that plane; and the length of this perpendicular, from the vertex to the centre of the picture, is *the distance of the picture or vertex:* this term will also be applied to the line itself when we have occasion to refer to it.

71. The *vertical plane* is one passing through the vertex, parallel to the plane of the picture.



72. Let X Y Z . . . and U T E S, in the figure, be the plane of the picture and the vertical plane; V in the latter being the vertex. Let B B″ be any straight line taken as an elementary original object: the rays from every point in B B″ will lie in one plane, the intersection, *b′ b″*, of which with the plane of the picture will be the indefinite perspective projection or *image* of B B″: the projecting plane (9) passing through any original line B B″ and the vertex will also intersect the vertical plane in a line V D, parallel to *b′ b″*. V D is *the director* of the original line.

73. If the original line B B″ were parallel to the plane of the picture, and therefore also to the vertical plane, its indefinite image and director would be parallel to the original line. But if B B″ be not parallel to the plane of the picture and vertical plane, it must intersect them both.

74. The point A, in which any original line cuts the plane of the picture, is termed its *intersecting point;* and D, in which it cuts the vertical plane, is termed the *station point* of that original line.

75. If a line V P be supposed to pass through the vertex, parallel to any original line B B″, it will cut the plane of the picture, if the original line itself be not parallel to that plane. This line V P is termed *the radial* of B B″, and the point P, in which this radial cuts the plane of the picture, is *the vanishing point* of the original line.

76. If any original line pass through the vertex, its radial will coincide with it, and the point in which such a line cuts the plane of the picture will not only be its common intersecting and vanishing points, but also the common image of all points in the original line, and consequently of the entire line itself.

77. It follows from these theorems that the original line, its director, its radial, and its image, all lie in its projecting plane, and therefore its image must pass through its intersecting and vanishing points; while its director must pass through its station point: and that these four lines must form a parallelogram, unless the original line be parallel to the plane of the picture; in which case the director and radial will coincide in one line, lying in the vertical plane, parallel both to the original and to its image.

78. Let us now consider the projection or image of any point B in an original line B B″, and the situation of that image in the indefinite one of the line, according to the position of the point B.

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* We need hardly allude to the modification of this assertion rendered necessary by the effects of atmospheric refraction. It is evident that the *forms* of objects which can be seen by the eye at one time are in no way influenced by these effects, which may therefore be neglected in treating this subject.

† There is a common toy which well illustrates this subject; we allude to a distorted image of a building, which, when viewed from a certain fixed point, presents a natural appearance. This distorted image is a correct section of a pyramid of rays supposed to proceed from the building to the point in question, and therefore when viewed from that true vertex, conveys the same impression that the building itself would do.

If B be at A, the intersecting point of B B″ (74); B and its image *b*[*] will coincide. If B lie in that part of A B which is on the contrary side of the plane of the picture to that on which the vertex is situated, its image *b* will lie between the intersecting and vanishing points, A, P, of the line: and if B be supposed to recede farther and farther from the former, the nearer to the latter will its image approach; so that the vanishing point is the *limit* of the successive images of points, farther and farther distant from the vertex, or it may be considered as the image of an infinitely distant point in the original line.

79. If the point B′ be situated between the intersecting and station points of the line, its image *b′* will be on the contrary side of the intersecting point to that on which the vanishing point P is situated; and if B be the station point D of the original line, it can have no image, or its image may be considered at an infinite distance from the vanishing point in either direction.

80. If the point B″ lie on the contrary side of the vertical plane to that on which the plane of the picture is situated, its image *b″* will lie on the contrary side of the vanishing point to that on which the intersecting point is situated; and, as before, the vanishing point may be considered as the limit of the images in this direction; or as the image of a point in the original line at an infinite distance from the station point in either direction.

81. Let two or more original lines be conceived as lying in an original plane Y Z, and suppose a plane W, which will be termed *the vanishing plane* of the original one, to pass through the vertex parallel to that original plane. The lines Y Z, D E, in which an original plane cuts the plane of the picture and the vertical plane, are called the *intersecting and station lines*, respectively, of that plane; and the lines W P, T V T, in which the vanishing plane cuts the same two planes, are called the *vanishing line* and *parallel of the vertex* to that original plane.

82. The intersecting, station, and vanishing lines, and the parallel of the vertex, are all parallel to each other, these four lines being the mutual intersections of two parallel planes by two other parallel planes.

83. The intersecting and station points (74) of any original lines, lying in one plane, are points in the intersecting and station lines of that plane: and the vanishing points of the same original lines lie in the vanishing line of that plane; for the radials of the originals must lie in the vanishing plane of that in which the original lines lie: and these radials must form with each other, and with the parallel of the vertex, angles respectively equal to those which the original lines form with each other and with the intersecting or station lines.

84. The vanishing line and parallel of the vertex to any plane will be those also of all planes whatever which are parallel to the first: and the radial and vanishing point of an original line will be those also of all lines parallel to the first, whether they lie in one plane, or in different ones.

85. The perspective projections, or images, of any number of original parallel lines, will be either parallel lines, parallel to the originals (73), or will be lines passing through the respective intersecting points of those originals (77), and through their common vanishing point; and the points in which the indefinite images of original lines, not parallel, cut one another, will be those of the points in which the originals cut one another.

86. It has been shown that the image of a line is parallel to that line's director; if, therefore, two or more lines have a common station point, and consequently a common director, or if the station points of two or more lines lie in one director, the images of those lines in either case will be parallel lines; and in these cases only can original lines, not parallel, have parallel images.

87. The ratios which exist between the definitive images and the original segments of lines are easily deducible, either geometrically or analytically; but as these theorems do not lead to rules of frequent practical utility, we forbear, with one or two exceptions, entering into them. Let B″ B represent a finite portion of an original line, bisected by the point B′, then the rays V B″, V B′, V B, and the radial V P of B″ B, will be harmonical lines; the definite image of the original line will consequently be harmonically divided by the images *b′*, *b*, of B′ and B, and by the vanishing point P. Conversely, if any segment of an indefinite image of a line be bisected by a point, the segment of the original line between its station point and the original of the image farthest from that station point will be harmonically divided by the originals of the other two points. If the point which bisects a finite line A B be the station point of that line, the image *a b* of A B will be bisected by the vanishing point P.

88. If an original finite line A B be parallel to the plane of the picture, its image *a b* will be to A B in the ratio of the *distance of the picture* (70) to the perpendicular distance of the plane, parallel to the picture in which A B lies from the vertex; and if A B be divided by a point D in any ratio, the image *a b* will be divided by *d*, that of D in the same ratio.

89. If an original plane figure be parallel to the plane of the picture, the image of that figure will be similar to the original; its periphery will be to that of the original, in the ratio of the *distance of the picture* to the perpendicular distance of the plane of the original figure from the vertex; and the area of the image will be to that of the original, as the squares of these lines. If, therefore, the distance of the picture be equal to that of the original parallel plane from the vertex, the image of an original figure in that plane will be equal, as well as similar, to the original: this may occur if the original plane coincide with that of the picture, or if the vertex be at equal distances from both, and lie between them; or if the vertex be infinitely and therefore equally distant from both on the same side.[*]

90. If an original plane, or planes, be parallel to the plane of the picture, their vanishing plane will coincide with the vertical plane: no such planes can therefore have any vanishing line.

91. If an original plane, or planes, be perpendicular to the plane of the picture, their vanishing plane will pass through the distance of the picture (70); consequently the vanishing line of such plane, or planes, will pass through the centre of the picture.

92. If an original plane pass through the vertex, its vanishing plane will coincide with it; the intersecting and vanishing lines will therefore coincide in one, as will also the station lines, and parallel of the vertex; and the images of all lines and plane figures, in such an original plane, will coincide in one line, that in which the plane itself cuts the plane of the picture.

93. The vanishing planes of two original planes will form the same dihedral angle that the original planes form with each other, and the line in which the vanishing planes intersect will pass through the vertex and be parallel to that in which the original planes intersect each other; it will, therefore, be the radial of this latter-named intersection. The intersection of the two vanishing planes, or this radial, will cut the plane of the picture in the vanishing point of the intersections of the original planes, which vanishing point will obviously be the intersection of the two vanishing lines determined by the two vanishing planes.

94. It follows, therefore, that the line in which two original planes cut one another will have for its vanishing point that in which the two vanishing lines of the original planes cut each other, and that the intersecting point of the common intersection of two original planes will be that in which the intersecting lines of those planes cut each other.

95. Every vanishing plane is supposed to have an *auxiliary* one, perpendicular both to it and to the plane of the picture, and therefore passing through the distance of the picture: this auxiliary vanishing plane will cut the plane of the picture in an *auxiliary vanishing line* perpendicular to the principal one, and passing through *its centre*, and also perpendicular to the intersecting lines of the original planes. The line in which the auxiliary vanishing plane cuts the principal vanishing plane is termed the *principal radial* of the original plane, or planes, to which the vanishing plane pertains. This principal radial is obviously perpendicular to the principal vanishing line, and meets it in its centre, which will consequently be the vanishing point of all lines in the original planes perpendicular to their intersecting lines.

96. The principal radial will form, with the distance of the picture and with the auxiliary vanishing line, angles equal respectively to the complement of the angle, and to the angle itself, which the original planes make with the plane of the picture.

97. The *auxiliary radial* of any vanishing plane is one lying in the auxiliary vanishing plane, and perpendicular to the principal radial; this auxiliary radial is that of all lines perpendicular to the original planes, the common vanishing point of which is the point in which the auxiliary radial meets the auxiliary vanishing line. This auxiliary vanishing point is the image, or projection of the points in which the auxiliary radial intersects all the original planes to which the principal vanishing plane is common.

98. The auxiliary vanishing plane, being perpendicular to the original planes, as well as to their vainishing plane, and to the plane of the picture, will intersect those original planes in lines perpendicular to their intersecting lines, and parallel to their principal radial.

99. It follows from these definitions, that the vanishing lines of all planes perpendicular to one or more parallel original planes will pass through the auxiliary vanishing point of those planes.

100. If the original plane, or parallel planes, be perpendicular to the plane of the picture, their principal radial will coincide with the distance of the picture. Their auxiliary radial will be parallel to the plane of the picture; and the vanishing lines of all planes, perpendicular to the original planes, will be parallel to each other, and perpendicular to the vanishing line of the original planes.

101. If a circle be supposed, described in an original plane on the point, as a centre, in which the auxiliary radial cuts that plane, all lines touching that circle will be intersections with that original plane, of vanishing planes of other original planes, inclined to the first in a certain angle. The point in which any one of these tangents to the circle cuts the intersecting line of the first original plane will therefore be a point in the vanishing line, to be determined by each such

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[*] We shall continue to employ the same conventional notation as before, designating an original point and line by capital letters, and their images by small, thus *a b* is the image of A B, and so on.

[*] From this theorem the relation between perspective projection, and projection on a co-ordinate plane by parallel lines, either perpendicular or oblique to that plane, will be at once perceived; the latter being the *limit* of the perspective image, as the vertex of the converging rays may be supposed to become more and more distant from the original; or the former may be considered as a perspective projection, the vertex being at an infinite distance.

vanishing plane respectively, while the vanishing point of each such intersection in the original plane will be a second point in the vanishing line of the plane inclined to the former. Therefore this vanishing line will be determined, if these two points be found.

102. For if a right conical surface be imagined formed round the auxiliary radial as an axis, having the vertex for its apex, and its side forming with that axis the complement to the angle the secondary original planes form with the first; the vanishing planes of these secondary original ones will touch that conical surface in a line, which will be the principal radial of each such vanishing plane; and therefore each vanishing plane will cut the first original plane in a line tangential to the circular section of the conical surface by that original plane. Again, the point in which these tangents to the circular section cut the intersecting line of the first original plane, will be common to the intersections with the plane of the picture of each vanishing plane respectively, or to the vanishing line as above stated.

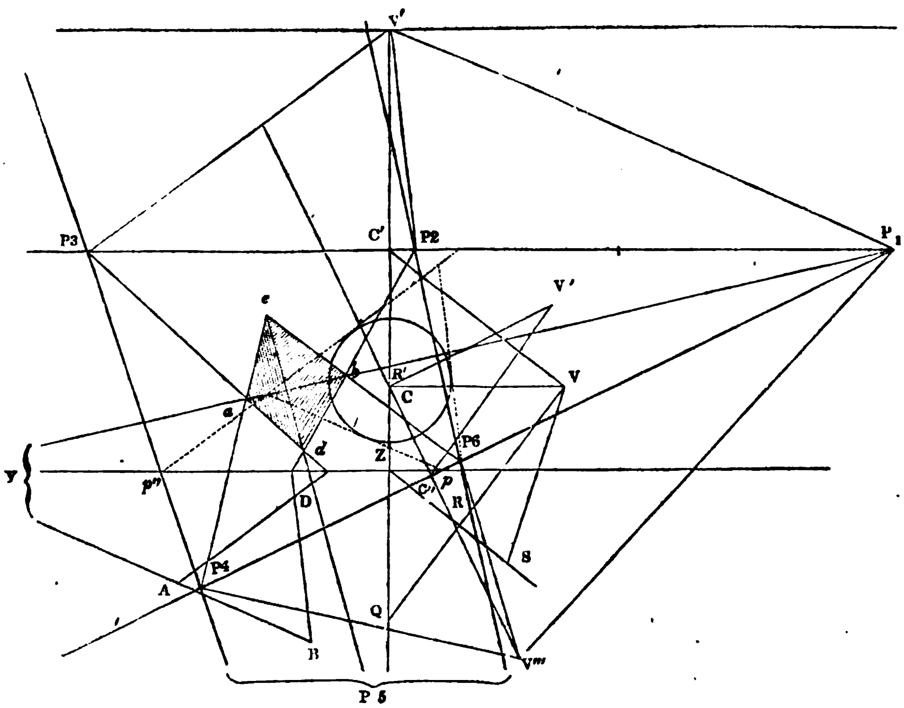
103. Constructions can be made, founded on these general theorems, by which the perspective projection of plane figures, or solids, may be obtained on a plane, taken to represent the plane of the picture, and all other original or vanishing planes brought to coincide with it by being turned round on their intersections with each other, and with the assumed plane of the picture.

104. If an original plane be supposed turned round on its intersecting line till it coincide with the plane of the picture, the relations of lines in the plane to each other, and to the intersecting line, will not be affected by so doing. And if the vanishing plane of that original plane be also turned round on the vanishing line in the *same* direction, the same observation will apply to the radials of original lines in the original plane, which will preserve their original relative position to that vanishing line: these radials will be therefore parallel to the original lines respectively, when both they and the original lines are brought into the same plane.

105. Since the principal radial is perpendicular to the vanishing line, this radial will coincide with the auxiliary vanishing line when the vanishing plane is brought into the plane of the picture.

106. But if, as frequently occurs, the constructions must be made on the supposition that the original plane has been turned round on its intersecting line in one direction, and the corresponding vanishing plane turned round on its vanishing line in the contrary direction; the radials will not be parallel to the original lines on this supposition, when the two planes coincide in one. These radials must therefore be drawn, making the same angles with the parallel of the vertex and with the auxiliary vanishing line, that the original lines make with the intersecting line, and with lines perpendicular to it.

107. As an example of the application of the foregoing principles, let it be required to draw the perspective projection of a tetrahedron, of a given magnitude, its position with respect to the vertex and the plane of the picture being also given or assumed.



108. Draw YZ* at pleasure, to represent the intersecting line of one plane of the solid; and take any point C for the centre of the picture. Through C draw CV' perpendicular to YZ for the auxiliary vanishing line of the plane (95), also draw CV parallel to YZ, and equal to the given distance of the picture (70); this, and the following steps in the construction, being founded on the supposition of the auxiliary vanishing plane (95) being turned round on CV', till it coincide with the plane of the picture. Make the angle CVC' equal to the complement of that at which the plane of the tetrahedron is assumed to be inclined to the plane of the picture (96), VC' will be the principal radial of the plane, and C' the centre of its vanishing line; consequently a line, $P_3 P_1$, drawn through C', parallel to YZ (82), will be that vanishing line. Draw VQ, perpendicular to VC', for the auxiliary radial, cutting VC' the auxiliary vanishing line, in Q the auxiliary vanishing point of the plane of the original tetrahedron.

109. Draw ZR parallel to VC' for the intersection of the auxiliary vanishing plane with the original one; R therefore, in which ZR meets VQ, will represent the point in which the auxiliary radial meets the original plane.

110. Make C'V' in that line equal to C'V, and through V' draw a parallel to YZ, which will represent the vertex and its parallel (81) brought into the plane of the picture by the turning of the vanishing plane on the vanishing line $P_3 P_1$.

111. Draw the equilateral triangle ABD for the face of the tetrahedron in its given or assumed position with respect to the intersecting line of its plane and the centre of the picture: this construction implies that the original plane of that face has been turned round on YZ, in the same direction the vanishing plane was turned round in, on $P_3 P_1$. Through V' draw the radials of the sides of the triangle parallel to them, and cutting the vanishing line in P_1, P_2, P_3, the vanishing points of those sides; the perspective images of which being drawn through the intersecting and vanishing points of the sides respectively, will form the image *a b d* of the given face.

112. If the original triangle had been assumed as lying between the intersecting and station lines of its plane, ABC would have been above the former line, and its image *a b d* below it; if that plane be supposed turned round in the same direction.

If rays be drawn from V' through A, B, and D, they will be found to pass through the images *a*, *b*, *d* of those points, and recourse must frequently be had to this mode of determining the image of a point in a line, when circumstances prevent the possibility of determining it by means of the image of another line, also passing through the original point. Or if the distances of any points in a line, as A, B, from its intersecting point, be set off from that point along the intersecting line, and the radial of the line be laid off along the vanishing line, from the vanishing point, of the original line; then lines drawn from the former points in the intersecting line to the point in the vanishing line, will cut the image of the original line in those of the points A, D.*

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* In this and some subsequent figures, the bracket with a letter to it is intended to signify that that letter applies to the point of convergence of the lines thus indicated; as for example in this figure, P_5 refers to the point in which $P_3 P_4$, and $P_2 P_6$ would meet. It must be observed also, that reference is in some places made to lines or points, not shown in the figures, to prevent confusion.

* Let Y be the intersecting point of an original line YA, and P its vanishing point, YP being its indefinite image; then if YA and PV be drawn in any, whatsoever, but opposite directions, parallel to each other, YA being made

113. By one or other of these principles, the images of any definite right lines, and therefore of any rectilinear figure, may be obtained. For one or more original lines may be always assumed as passing through one or more points, the images of which are required; so that the indefinite images of the assumed lines will give those of the points sought, by its intersections with the images of other lines, in which those points lie: and these assumed lines may be so taken as to define the images with more precision, or to obviate the necessity of drawing radials of lines but little inclined to the intersecting lines of the planes in which they lie. Z R is the perpendicular distance of the point in which the auxiliary radial cuts the original plane from its intersecting line; R therefore is the centre of the circular section of the conical surface before alluded to (102). Make Z R′ in Z V′ equal to Z R: draw V S to make at V, with V R, the complement of the angle at which the faces of the tetrahedron are inclined to each other. From R′, as a centre, with R S for a radius, describe a circle. Draw lines to touch this circle, parallel; respectively to A B, B D, A D. Through the point *p*, in which the tangent parallel to A B cuts Y Z, and through P_1, the vanishing point of A B, draw $P_1 P_4$, the vanishing line of the face of the solid meeting the face A B D in A B: and on the same principles $P_2 P_6$, $P_3 P_4$, the vanishing lines of the two remaining faces are found; then $P_4 P_5$, P_6, in which these vanishing lines intersect each other, will be the vanishing points (94) of the edges of the solid, and lines accordingly drawn from *a*, *b*, *d* to these points will complete the image of the tetrahedron.

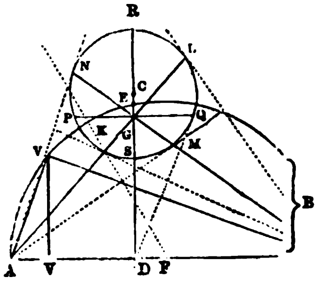
114. Simple as is the construction above described, for finding the vanishing lines of planes making any proposed angle with a given plane, it may frequently be avoided by availing ourselves properly of the symmetry of the solid to be delineated. Thus, in the example before us, after finding the image, *a*, *b*, *d*, of one face of the tetrahedron, we might have determined the image of the centre of that face by drawing those of the perpendiculars on each side of the triangle from the opposite angles; a line drawn through this centre and through Q would be the image of one, perpendicular to the plane of the triangle (97); this line would pass through the vertex of the pyramid, or through the angular point in which the other three faces meet, by finding the image of this point, which can be easily done by first determining the intersecting point of the perpendicular, and the intersecting line of any plane in which it lies; then lines drawn from *a*, *b*, and *d* to this image *e* would complete the figure.

115. When a vanishing line is obtained, it is frequently requisite to determine its centre and distance, or its principal radial; this is done by the construction employed to determine the vanishing line $P_1 P_3$. Thus, to determine the centre, &c., of vanishing line $P_1 P_4$, draw a parallel to it through C, making C V″ equal C V, the distance of the picture; also draw C V‴ perpendicular to the vanishing line for its auxiliary one, cutting the former in C″ its centre. Make C″ V‴ equal C″ V″, the principal radial; then V‴ P_1, V‴ P_6, V‴ P_4 being drawn, they will be the radials of the three sides, *a b*, *e b*, *e a*, of the face of the solid, and will be found, accordingly, to make angles of 60° with each other (83). The radial V‴ P_1 will also be found equal to V′ P_1, these lines representing one and the same line, only brought into the plane of the picture by the rotation of two different vanishing planes on their vanishing lines.

116. The perspective projection of a curve may always be found by means of the images of a sufficient number of points in the original, or by the projection of some inscribed or circumscribed polygon; if the curve be a plane one: in this case the image of a tangent to the original curve will be a tangent to the image of that curve. For if the image of the tangent meet that of the curve in more than one point, these points must be the images of points in the original curve through which the original of the tangent must pass: which is contrary to the supposition. But there are some theorems regarding the perspective projection of a circle, and constructions founded on them, which ought to be well understood by the draughtsman.

117. The rays from the circumference of a circle, obviously, form a conical surface, the section of which, by the plane of the picture, will be one of the conic sections. If the original circle, or base of the cone of rays, be parallel to the plane of the picture, the image will be a circle, the radius of which will be to that of the original in the ratio of the distance of the picture (70) to the distance of the plane of the original circle from the vertex (89).

118. If an original circle do not touch, or cut, the station line of its plane, its image will be an *ellipse* wherever the plane of the picture may be; unless the section by the plane of the picture happen to be a subcontrary one, an exception to which we shall recur on a subsequent occasion. If the station line be a tangent to the circle, its image will be a *parabola*; and if that line cut the circle, the image will be the opposite branches of an *hyperbola*, lying on contrary sides of the vanishing line of the original plane (80).



119. Let KNLM be an original circle, AB being the station line (81); the image of the circle will in this instance, be an ellipse. Draw the diameter C D to the circle, perpendicular to A B; and let G be the point in C D through which the chords of the tangents from all points in A B pass, according to the well known property of the circle. Let V represent the vertex, the vertical plane being supposed to be turned round on the station line A B, till it coincide with the plane of the circle; V V′ being the director perpendicular to the station line. Make D E, in D R, equal to the tangent to the circle drawn from D; bisect V E by a perpendicular, cutting A B in F; on F as a centre, with F V or F E for a radius, intersect A B in A and B, and draw lines through these points and through G; K L, M N will be the originals of the axis of the elliptic image of the given circle, wherever the plane of the picture may be assumed, and at whatever angle that plane and the vertical one be inclined to the plane of the circle.

120. If A, B be two points in A B, such that each is in the chord of the tangents from the other point produced, then, from the properties of the circle, A E, B E will be equal respectively to the tangents A N, B L, drawn from those points; and the square on A B is equal to the sum of the squares on A N, B L, or on A E, B E. E therefore lies in the circumference of a circle described on A B as a diameter. Since the angle A V B, made by the directors of A L, B N is a right angle by construction; the images of A L, B N will be perpendicular to each other, and parallel, respectively, to those of the tangents A N, A M; B L, B K having the same station points with the chords K L, M N. Again, since A L is harmonically divided in K and G, and B N in M and G, the image of K L will be bisected by that of G, and the image of M N will be also bisected by the image of G (87): hence those images being diameters to the ellipse, mutually bisecting each other, and parallel reciprocally to the tangents which are the images (86) of A N, A M, B K, B L, the images of K L, M N must be conjugate diameters, and since those diameters are perpendicular to each other, they must be the axes.

121. If V′, the foot of the director V V′, coincided with D, or if V V′ were in the auxiliary vanishing plane, the perpendicular to V E would be parallel to A B, and P Q, S R would be the originals of the axes, which accordingly would be parallel and perpendicular to the intersecting line. But in every other position of V V′, with reference to the circle, these axes must be oblique to that intersecting line, while the angles they form with it will vary according to the distance of V′ from D, and according to the length of the director V V′.

122. The points G and E will not be common to two or more concentric circles, the originals of the axes of the elliptic projections of concentric circles will not be in the same straight lines, nor will they have the same station points, except in the case of V′ and D coinciding, when the originals of the axes will be parallel and perpendicular to A B.

123. If A B touched or cut the original circle, the originals of the axes, &c., of the parabolic or hyperbolic projections might be found on the same principles: but as these curves do not often occur in practical perspective drawing, we shall not dwell on the subject.

124. The only solids with curved surfaces that need be considered are, the cylinder, the cone, and the sphere.

125. If a line be conceived to pass through the vertex, parallel to the axis of a cylinder, whether right or oblique, two planes passing through this parallel will touch the cylinder in two lines of its surface, also parallel to its axis, which will be the originals of the straight outline of the perspective projection, or image, of that cylinder.

126. These two tangential planes will cut the plane of the base of the solid, or that of any section of it whatsoever, in two lines, which will be tangents to the curve of that section. And the parallel to the axis through the vertex is obviously the radial of that axis, which, by its intersection with the plane of the picture, will determine the vanishing point of that axis; and this vanishing point, it must be remembered, is the image of the point, in any original plane, cutting the cylinder in which the two tangents to the curve of the section in that plane meet, which have been shown to be the originals of the outline of the solid.

127. If therefore the image of the base or of any section of the

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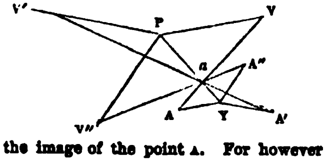
equal to the distance of a point A in the original from its intersecting point, and P V equal to the length of the radial of the line; then A, V being joined,

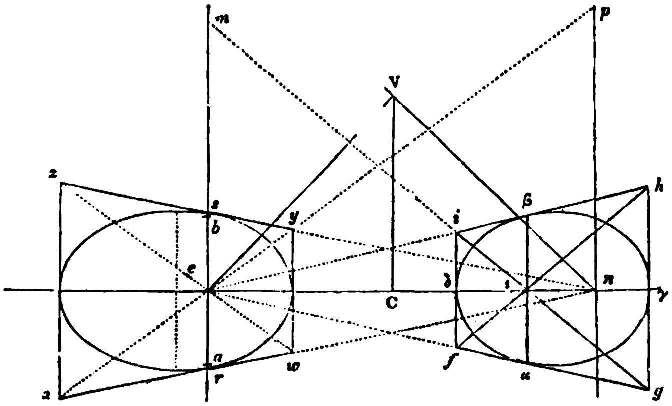


A V will cut Y P in *a*, the image of the point A. For however the lines Y A, P V may be drawn, the triangles Y A *a*, *a* V P will be similar; the antecedents Y A, P V being constant, the consequents Y *a*, *a* P must be so likewise. When this principle is applied, the two parallels may be so taken that the line V A joining their extremities may cut Y P at nearly right angles, and so define the point with precision.

cylinder by a plane be obtained, lines drawn tangents to this image through the vanishing point of the axis will give the straight parts of the outline of the solid; these outlines must also be tangents to every other curve which is the image of any section of the original cylinder.

128. If a line pass through the vertex and the apex of a cone, and meet the plane of its base, or any other plane cutting the cone, two lines drawn through the point of intersection tangents to the curve of the section will be the intersections with that plane of two others passing through the vertex and tangential to the surface of the solid, and these two planes will touch the cone in lines which will be the originals of the outline of its image.

129. The ray just mentioned passing through the apex of a cone is analogous to the radial of a cylinder passing through the vertex, the cylinder being considered as a cone, with its apex infinitely distant.



130. If the line through the vertex and the apex of a cone, or the ray of that apex, be parallel to the plane of its base, or of any section, the tangents to the base lying in its plane, or in that of such section, must be drawn parallel to that ray, and the image of the apex will be the vanishing point of these parallel tangents.

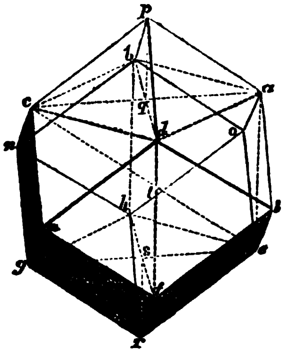
131. Let C be the centre of the picture; ab, bisected in e, being given as the image of a diameter, parallel to the plane of the picture, of a sphere* e, therefore being the image of its centre (88). Draw an indefinite line through C and e, and CV perpendicular to it, equal to the assumed distance of the picture; take any point ϵ at pleasure in eC, but as far from e as convenient; draw $\alpha\beta$ through ϵ perpendicular to Ce, making $\epsilon\alpha$, $\epsilon\beta$, equal to ea, eb. Join Ve and set off its length each way from e to l and m along a line perpendicular to Ce.

132. By this construction lm is a vanishing line, of which e is the centre, Ve equal to its principal radial, and Ce its auxiliary vanishing line (95); l and m will obviously be the vanishing points of the diagonals of every square, lying in original planes having lm for their vanishing line, the sides of that square being parallel and perpendicular to the intersecting line of its plane; accordingly the quadrilateral $fghi$ is the image of such a square, lying in such a plane, and the line $\alpha\beta$ being made equal to the given image of a diameter of the sphere, $\alpha\beta$ and ab are the images of equal original lines parallel to the picture and equally distant from it, or both lying in a plane parallel to that of the picture. If therefore an ellipse be described in $fghi$, touching the sides in the points $\alpha\beta\gamma\delta$, and having its transverse axis in Ce, this ellipse will be the image of an original circle equal to a great one of the sphere, and having its plane parallel to that passing through the vertex and the centre of the sphere, or this original circle may be regarded as the oblique plan, on a plane parallel to it, of the section of the sphere by the vanishing plane, the projecting lines being parallel to the plane of the picture.

133. Draw Vn perpendicular to Ve, cutting eC in n, and through n draw a vanishing line perpendicular to en, or having en also for its auxiliary vanishing line; make no, np, each equal to the auxiliary radial Vn; make er, es,† in lm, each equal to the *semi-conjugate* axis of the ellipse last drawn, and complete the trapezium $wxyz$ as the image of a square having op for its vanishing line, and its sides parallel and perpendicular to the intersecting line of its plane. An ellipse described in $wxyz$, having its transverse axis in en, will be the outline of the sphere.

134. For n being the auxiliary vanishing point of the plane of the original of $fghi$, op is the vanishing line of all planes perpendicular to that original plane, and intersecting it in lines parallel to the plane of the picture. The original square of the quadrilateral $wxyz$ is therefore perpendicular to the plane of the original of $fghi$, or to the vanishing plane passing through the vertex and centre of the sphere. Now it will be seen that the conjugate axis of the ellipse in $fghi$ is the *oblique plan* (59) of the chord of the tangents from the vertex to the section of the sphere by the vanishing plane, which chord of the tangents must be a diameter of the small circle of the solid, constituting the original of its apparent outline; this small circle being the base of the cone of rays tangential to its surface (62), and having its plane perpendicular to that of the vanishing plane passing through the vertex and centre of the sphere; $wxyz$ is consequently the image of the square circumscribing the circular base, and the inscribed ellipse that of the circle itself, or this ellipse is the outline of the sphere.

135. If the distance of the vertex (70) be supposed to be indefinitely great, compared to the magnitude of the object to be represented, the pyramid of rays may be conceived to become a prism, or the rays to be parallel. On this supposition the vanishing points of the lines of the original object would be indefinitely distant from the centre of the picture, and the images of parallel original lines would be parallels. The isometric projection of a parallelopiped (57) is obviously a limited case of this kind, the limitation being necessary from the object in view, which induces us to adopt that kind of projection. But there are occasions on which it is desirable to delineate rectilinear objects pictorially, which from their small relative size, and from other considerations, do not require the application of perspective projection, and which would not be adequately represented by an isometric one. In such cases the draughtsman may readily accomplish his purpose by combining the principles of projection on co-ordinate planes with perspective, as in the following example.



136. Let a hexagonal figure, $abcdefg$, be drawn, with the condition that each pair of opposite sides shall be parallel, and consequently equal; from the angles a, c, f draw lines parallel to the alternate sides, and meeting in a point d, and from the intermediate angles b, e, g draw lines parallel to the remaining sides respectively, and meeting in h. The figure thus formed will be the *orthographic* or *orthogonal* projection of a cube, under certain unknown conditions of inclination of the plane of projection to the projecting lines, and of these to the original planes of the solid.

137. The projections of the centres of each face of the cube, as q, may be found by drawing the diagonals, as ac, bd, and if lines be drawn through the centres of each pair of opposite faces, as pr, which lines will obviously be parallel to the edges of the solid, and perpendicular to the planes of the faces, they will pass through the vertices of right pyramids placed on each face. By making the altitude of these pyramids, as pq, equal to half the projection of the parallel edges bf, &c., of the solid, we obtain the remaining angles, l, m, n, o, p, r, of the solid termed a rhomboidal dodecahedron, one diagonal of each face of which is one edge of the original cube.

138. By previously constructing the projection of a cube in the manner just described, the sides of which will furnish a scale of the ratio of the projections of any lines parallel to the edges of that cube, the projection of any parallelopiped may be obtained, and from this again the image of any symmetrical solid deduced. In this manner

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* ab need not be perpendicular to the line Ce; it is shown so in the figure, to avoid unnecessary lines; but as every diameter of the sphere which lies in a plane parallel to that of the picture is also parallel to that plane, ab may make any angle whatever with Ce.

† The points ra, sb, are not the same, though they cannot be distinguished in the figure.

the forms of crystals can be drawn with the most perfect accuracy, and a most distinct conception obtained of them and of the relative position of their planes. And by analogous constructions diagrams of the theorems of solid geometry may be drawn, which would greatly facilitate the study of analytical geometry.

139. It has been stated that perspective projection is principally employed to furnish a pictorial outline of a building, machine, &c., or to convey an idea of an object of that description to the spectator, but to do this the perspective outline must excite in his mind the ideas of the real forms of that object in their relative situations, such as would be excited by the object itself, when viewed from a given point. But there are limitations to the apparent forms of objects, arising from the structure of the eye and the laws of vision, which the draughtsman must never lose sight of, when he practically applies the purely geometrical principles we have deduced, or otherwise he may produce an accurate projection of an object which would be perfectly unintelligible to an ordinary spectator; as the outline of the sphere, deduced in the preceding example, would be to an uninitiated eye.

140. Since the eye can only embrace at one time a very limited field of view, in order to see the whole of an object without changing the place of the eye, the spectator must not be nearer to it than a certain distance, for otherwise he would have to turn his head to see the successive parts, and at each such change of position the apparent forms of those parts just escaping from his view would undergo a considerable modification, arising from the structure of the eye itself. Few persons are aware of these modifications, owing to the effects of habit and the result of the judgment, which induce us unconsciously to assign the real and constant forms we know the parts of the object to possess to the apparent forms under which those parts are seen. Indeed it requires a considerable degree of abstraction and education of the eye to make the mind cognisant of the fact, that it is never the real form of an object that presents itself, a truth familiar to artists, who know that persons when first attempting to draw an object before them by eye, invariably draw it as they know it to be, and not as they really see it.

141. We have stated that the perspective projection of an object is rarely viewed from the precise point from which alone it ought to be viewed, so that the forms in the projection may suggest the ideas of the original forms whence they were deduced; consequently the outline should not in any part deviate greatly from what we may call the average form under which the true one would present itself to the eye. To effect this accordance the draughtsman must assume his point of view, or *vertex*, at such a proportional distance from the object itself, or from the imaginary model of it, that the rays from the points of it farthest apart, may not contain an angle greater than 60° at most, and, if circumstances allow of it, of not more than 45°. In short the pyramid of rays from an object to the vertex should be included within a cone the angle at the apex of which is not greater than that above named.

142. The distance of the vertex from the object being determined from these considerations, and its position with respect to the various parts of the original object decided on, by the conditions of the kind of view of that object it is proposed to delineate, the position of the plane of the picture should, generally speaking, be perpendicular to the axis of the cone or pyramid of rays before alluded to; but the following principles must determine more accurately its situation.

143. From the frequency of their occurrence under circumstances favourable for the observation, the eye is accustomed to the apparent convergence of long horizontal parallel lines, as in streets, aisles of cathedrals, long avenues of trees, or walls, &c., but perpendicular parallel lines are rarely if ever long enough to cause this optical effect. Now we have proved that the projections of parallel lines never can be parallel unless the originals are parallel to the plane of the picture; if therefore the draughtsman were to assume that plane *not* parallel to the vertical lines of a building, &c., the convergence of the projections of these lines would offend the eye of a person looking at his drawing, as being at variance not only with his judgment of the real parallelism of the lines in question, but even with his daily uncultured observation. But there is another optical phenomenon regarding the appearance of long parallel lines, which we must briefly allude to, because it throws considerable light on the distinction between the apparent forms of objects as seen by the eye, which forms are functions of the angles solely under which the original forms are seen, and the figures on a plane, resulting from the section by that plane of the pyramids of rays from those original forms, which sectional forms are functions of the arcs subtending those angles.

144. If a spectator stand opposite two or more long horizontal parallel lines, as those of the façade of a long building, or of a garden wall, for example, he very palpably perceives the apparent convergence of these parallels in both directions, as they recede from him to the right and left; on reflection, he is therefore convinced that the apparent form of the really parallel straight lines are curves, produced by the varying angles under which the equal ordinates between the parallels are seen, as they become more and more distant from the eye.

145. The parallel projections of such long horizontal lines, which would result from the plane of the picture being assumed parallel to the originals, would reassume their natural apparent curvature, if viewed from the correct vertex; but if not, their parallelism would offend the eye as being at variance with daily experience, and still more would any attempt to draw on a plane the apparent curvature of the lines in question be reprehended as being contrary to the verdict of the judgment, which decides that the originals, being straight lines, ought not to be represented by curves.

146. The draughtsman, consequently, must never assume his plane of the picture parallel to the longest side of a building, &c., however much he may be tempted to do so from the facility of making his constructions under this condition, when the projections of such a side would subtend at the vertex an angle of more than 15° or 20°.

147. Keeping these conditions in view, the draughtsman may assume the distance of his picture, or its distance from the vertex, entirely according to his own convenience, since it is only the absolute magnitude of the image or projection which is altered by the different distances of the picture, the figure of the image being similar on all parallel planes, as long as the vertex and object remain the same. For the sake of facility of construction, he will generally assume his plane of the picture as coinciding with some principal vertical line of the object or model.

148. The *shadow* of any object is obviously the *projection* of it on a surface, by converging on parallel lines or rays, according as the luminary is supposed to be at a finite or at an infinite distance, as the sun may be considered to be as regards terrestrial objects. When, therefore, we have obtained the projection of an object by the principles just explained, they will also enable us to obtain the projection of its shadow on one or more planes or surfaces, as supposed to be cast by an artificial light or by the sun; the problem being simply to determine the projection of the intersection of a pyramid or prism of rays passing from a given or assumed point through the points of a projected object.

149. If the object be *perspectively* projected, and the luminary be the sun, the vanishing point of the parallel rays, whose direction must be given or assumed, will represent the sun, since that vanishing point is the image of a point infinitely distant.

150. Although our power of forming correct conceptions of the true form of an object, as derived from a projection or pictorial representation of it, is much increased by the addition of light and shade, and of shadows of the object correctly projected by rules identical with those by which its outline was obtained, yet as soon as we thus approach the domain of a higher art, that of painting, the mathematical precision of the shadows we should obtain by our rules must yield to more important considerations connected with the art alluded to. Hence it is that the draughtsman seldom applies the geometrical principles for finding the true shadows of the engine, building, or analogous object, the outline of which he has delineated; for at an early stage of his practice in drawing he ought to have acquired sufficient knowledge of art to be able to add to his outline the effect of light and shade without any gross violation of truth of nature, and with a better pictorial effect than he could ensure by geometrical rules. We shall consequently only give two simple examples relating to the projection of shadows, rather as affording additional illustrations of the principles of projections, than for any practical utility as regards the specific subject of shadows.

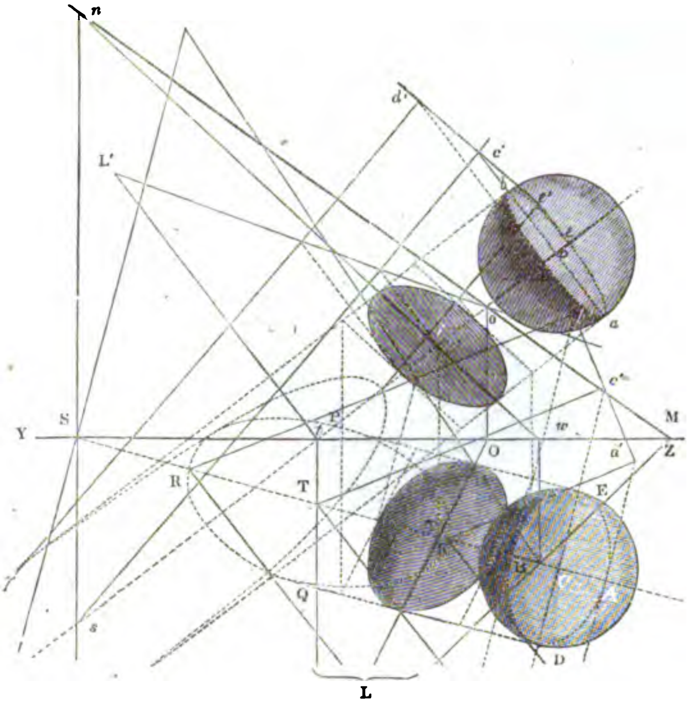
151. Let the line C S, cs, passing through the centre C, c, of a sphere, be given as the direction of the solar rays; it is proposed to determine the shadow of that sphere on the given plane L M n. It is obvious that the problem is to determine the section of the right cylindrical surface, formed by the system of parallel rays, which are tangential to the spherical surface, by the plane L M n; and that the great circle of the sphere passing through the points in which these rays touch it will be the base of the cylinder, and the boundary between the illuminated hemisphere and that in shadow.

152. Draw cc', Cc', perpendicular to the projections of the ray, and make them respectively equal to the distances of the centre of the sphere from the co-ordinate planes; C′s, c' T, drawn through the points in which the given ray cuts the co-ordinate planes, will represent that ray brought into the co-ordinate planes by the turning round of its projecting planes on its projections; draw $a'b'$, $d'e'$, perpendicular to c' T, $c's$, making them equal to the diameter of the sphere; then lines drawn through a', b', parallel to c' T, will represent the two rays, touching the surface of the solid and lying in the projecting plane of the given ray brought into the co-ordinate plane along with that ray: these lines will cut C T in Q R, the vertices of the major axis of the elliptic outline of the shadow of the sphere on the co-ordinate plane. The conjugate axis Q P will be given by drawing lines parallel to C T tangents to the projection of the sphere; for these last parallel tangents will be the boundaries of the projections of the cylinder of rays. Lines drawn through a', b', parallel to Cc', will cut cT in the vertices A, B, of the conjugate axis of the elliptic projection of the great circle, separating the illuminated hemisphere from that in shade; a diameter D E to the circular projection of the sphere, drawn through c perpendicular to C T, will be the major axis of this ellipse.

153. For the plane of the great circle, of which A D B E is the projection, is obviously by the construction perpendicular to the given ray, and the plane of this circle is cut by the projecting plane of the given ray C T in the original of A B, while the diameter D E is the projection of the intersection with the plane of the same great circle, by a plane passing through the given ray C S, cs, and perpendicular to the plan-

projecting plane (9) of the given ray. This perpendicular plane must, therefore, be the elevation-projecting plane of the given ray.

154. By the same construction applied to the other projection, the elliptic elevation $adbe$, of the circle separating the light and shade on the sphere, and the elliptic shadow of the sphere on the vertical co-ordinate plane, may be obtained.

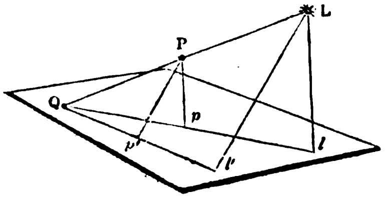


155. It is clear that in this example the two elliptic outlines of the shadows of the sphere on the co-ordinate planes, must cut Y Z in two common points; because the segments of the ellipse on either side of Y Z of each outline is the projection on the one co-ordinate plane of that portion of the cylinder of rays which forms on the other co-ordinate plane the portion of the outline of the shadow on the same side of Y Z. t L, perpendicular to Y Z, is the trace of the elevation projecting plane of C S, $c\,s$; o, O, is the point in which this same plane cuts the trace of the given plane, consequently L O is the plan of the intersection of those two planes, and T', in which this line is cut by the plan of the ray C S is the intersection of that ray, and the given plane; the elevation t' of the same intersection may be obtained by applying the same constructions to the other traces and projections.

156. The two pair of parallel planes, which are respectively perpendicular to the co-ordinate planes, and therefore to each other, and which are parallel to the given ray, touch the sphere in the points A, a; B, b; D, d; E, e. These four planes will be cut by the plane L M n in a parallelogram, the sides of the projections of which must be parallel to those of the ray C S, c, s, and to the lines L O, $w\,n$. Draw t L' perpendicular to $o\,t$, and make t L' equal to t L; join o L', which will represent the intersection of the projecting plane with L M n; draw lines through d', e', parallel to $c'\,s$, and from the points in which these parallels cut o L' draw parallels to L't to cut $o\,t$; again lines drawn through these last intersections parallel to $w\,n$ will be the two sides of the elevation of the rectangle above mentioned; the parallel tangents at a and b will complete the figure; and $o\,t$, $w\,n$, will cut the opposite sides in the points in which the elliptic outline of the shadow of the sphere will touch those sides, or the points which represent the shadows of d, e, a, and b.

157. The plan of this parallelogram may be determined in the same manner, or by the other constructions explained for determining the projections on the other co-ordinate plane from those already determined on the first, and which are sufficiently indicated in the figure to render further description of them unnecessary.

158. If L represent a luminous body, and P a point, then, by



imagining a plane to pass through them, the intersection of that plane with the plane on which the shadow is cast will cut the ray L P in Q, the shadow of the point. To determine this intersection, we have only to draw two parallel lines through L and P, in *any* direction, and determine the points l and p, or l', p', in which these parallels meet the plane of the shadow: then $l\,p$, L P being drawn, they will cut each other in Q, the shadow of the point. This is the principle employed in the following construction.

159. Let $a\,b\,c\,d\,e\,f\,g$ be the perspective projection of a cube, C being the centre of the picture, C V the distance of the picture, P, X the vanishing line of the face $a\,b\,c\,d$, and Y Z its intersecting line; while Y' Z' is that of the face $e\,f\,g$, parallel to the former. Let Y Z and W Z be given as the vanishing and intersecting lines of a plane, on which the shadow of the cube, as cast by the luminous * body given in position, is to be determined.

160. X Z, X W, being drawn, will represent the lines in which the plane of the shadow intersects those of the parallel faces of the solid (94). If we suppose planes parallel to that of the picture to pass through the various points of the cube, as a, these will intersect the two original planes in lines, as $a\,\alpha$, $a\,a'$, parallel to Y Z, Z W; and a line, $\alpha\,a'$, through the point of the cube, parallel to the auxiliary vanishing line, will meet $a\,a'$ in the point a',* which will be the oblique projection of the point a on the plane of the shadow. Therefore, by drawing lines through the points a, b, c, d, parallel to Y Z, to cut X Z in $\alpha, \beta, \ldots \delta$, then lines parallel to W Z, through $\alpha, \beta, \gamma \ldots \delta$, will cut lines parallel to W C', drawn through a, b, c, d, in the oblique projections of those points on the plane of the shadow, and by referring $e, f, g \ldots$ to W X, in the same way, we obtain the oblique projections of the other angles of the cube.

161. Since the sides of the cube $a\,b$, $c\,d$, $e\,f$, &c., are parallels, their oblique projections will be parallels (59), consequently the images of these parallels $a'\,b'$, $c'\,d'$, $e'\,f'$, &c., will have a common vanishing point P' in the vanishing line of the plane in which the oblique projections lie; for the same reason, $a'\,d'$, $b'\,c'$, $f'\,g'$, &c., will have a common vanishing point P'_2 in Y X. Now it is obvious that the vanishing points P'_1, P'_2, are, by an extension of the principle, the oblique projections on the plane of the shadow of the vanishing points P_1 P_2 of the original sides of the cube; consequently the former may be determined from the last-named vanishing points by simply drawing lines through them parallel to W C to cut Y X in P'_1, P'_2.

162. If k had been given as the image of the point in which a line through the luminary perpendicular to the plane Y Z met that plane, the image * of the luminary would be determined by making k*, drawn to the auxiliary vanishing point Q, the image of the given perpendicular height of the luminary above the original plane. A line through * parallel to W C' will meet C'k produced in l, the oblique projection of the luminary on the plane Y Z.* Its oblique projection l' on the plane of the shadow may be either determined as those of a, b, c, d, &c., were, or by drawing a line, as $a\,l$, at pleasure, to cut the vanishing line X P in some vanishing point; this vanishing point may be transferred to X Y by a parallel to C W; then a line drawn through a', the oblique

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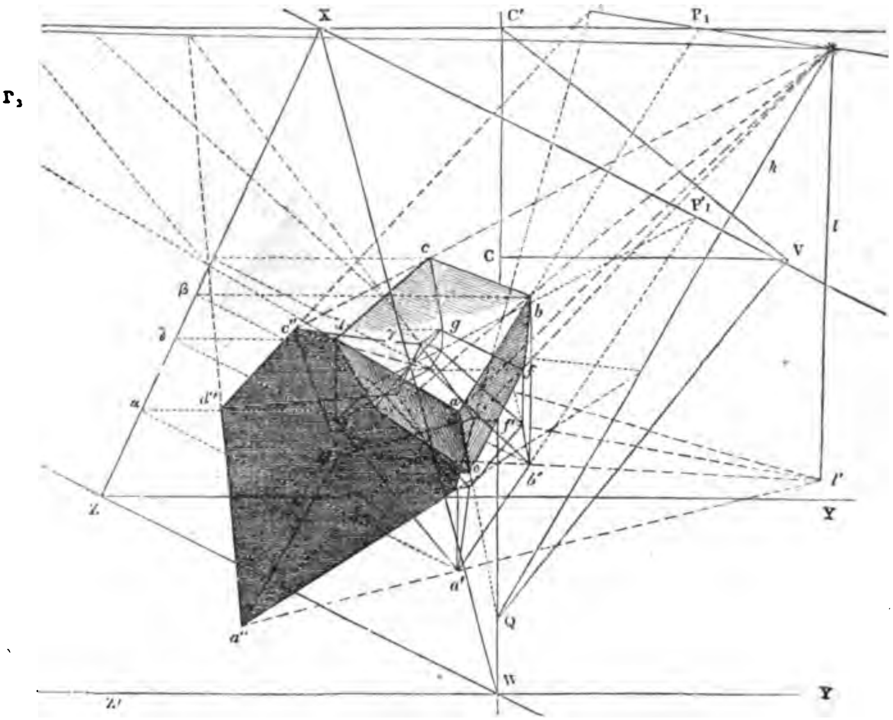
* That is to say, a' is the *perspective image* of the oblique projection of the original point of which a is the perspective image.

projection of a, to this transferred vanishing point, will cut $*l$ produced in l', the oblique projection of the luminary on the plane of the shadow.

163. Draw lines through l' and through the oblique projection a', b', c', d', e', &c., intersecting each such line by the luminous ray $*a$, $*b$, $*c$, &c., in the shadows a'', b'', c'', &c., of the angles of the cube,



and these points being joined, the figure thus produced will be the image of the shadow of the cube on the plane as proposed.

164. The oblique projecting lines $a\,a'$, &c., were assumed parallel to the picture and its auxiliary plane, simply for facility of construction, or else the points a, b, c, e, f, &c., might, as well as the luminary, have been projected on the plane of the shadow by lines in any direction, provided these lines were parallels according to the above principle (158).

165. Draw lines through * and P_1, P_2, and Q, the vanishing points of the sides of the cube; then the images, as $a''b''$, $c''d''$, $e''f''$, of the shadows of the parallel lines of the original solid will meet in a point in the corresponding line drawn through * and the vanishing point of those originals. For the planes passing through * and the parallels ab, cd, ef, &c., must intersect in a common line, passing through * and parallel to those originals: this common intersection will therefore have the same vanishing point, P_1, as those originals; the line $*P_1$ represents that common intersection. Now the shadows $a''b''$, $c''d''$, $e''f''$ are the intersections of the before-mentioned planes by another, namely, by the plane of the shadow, and these intersections, $a''b''$, $c''d''$, &c., must meet each other in a point in $*P$, the common intersection of the planes passing through * and the original lines. The same reasoning applies to the other shadows of the corresponding parallel sides of the cube.

PERSULPHOHYDROCYANIC ACID. Synonymous with *hydropersulphocyanic acid.* [CYANOGEN.]

PERSULPHOMOLYBDENIC ACID. [MOLYBDENUM, *Sulphides of.*]

PERTURBATIONS. [GRAVITATION.]

PERTUSSIS. [HOOPING-COUGH.]

PERUVIAN ARCHITECTURE. Remains of ancient Peruvian buildings are dispersed over the western parts of South America, from the equator to 15° S. lat., especially over the Montaña. Nothing certain is known of their date, but the oldest is attributed to Manco Capac, the traditional founder of ancient Peruvian civilisation, who is said to have flourished about three centuries before the conquest of Peru by the Spaniards, or 1200 A.D. These remains are characterised by simplicity, symmetry, and solidity. There are no columns, pilasters, or arches, and the buildings exhibit a singular uniformity and a complete want of all exterior ornaments. The structures, whether mere walls or buildings, are all of stone; the blocks in some instances being squared and laid in horizontal courses, in others consisting of huge polygonal masses; while in both the doorways and openings for light are formed of jambs inclined towards the top, and covered with a large stone as a lintel; being, in fact, in all respects almost the exact counterpart of the Pelasgian masonry of Greece and Italy [PELASGIAN ARCHITECTURE]—a circumstance the more remarkable since, if Peruvian tradition be not altogether at fault, some eighteen centuries must have elapsed between the latest example of Pelasgic construction in Europe and the earliest in Peru.

The great road of the Incas, which runs from Quito to Cuzco and the table-land of the Desaguadero, is made of enormous masses of porphyry, and it is still nearly perfect in several parts of the Montaña. Humboldt obtained an ancient Peruvian cutting instrument, which had been found in a mine not far from Cuzco: the material consisted of 94 parts of copper and 6 of tin, a composition which rendered it hard enough to be used nearly like steel. With instruments made of this material the Peruvians cut the enormous masses of which their buildings were composed. Some of the buildings near Cuzco contain stones 40 feet long, 20 feet wide, and nearly 7 feet thick. These stones are fitted together with great skill, and, as it was supposed, without cement. But Humboldt discovered in some ruins a thin layer of cement, consisting of gravel and an argillaceous earth; in other edifices, he says, it is composed of bitumen. These stones are all parallelopipedons, and worked with such exactness that it would be impossible to perceive the joinings if their exterior surface were quite level; but being a little convex, the junctures form slight depressions, which constitute the only exterior ornament of the buildings. The doors of the buildings are from 7 to 8½ feet high. The sides of the doors are not parallel, but approach each other towards the top. The niches, of which several occur in the inner side of the walls, have the form of the doors.

The walls of Cuzco are formed of huge polygonal blocks of limestone, from 8 to 10 feet in length, and the same in width, and admirably fitted to each other without cement, precisely like those shown in the cut of the Walls of Epirus in PELASGIAN ARCHITECTURE; but it is remarkable that not only is the masonry almost perfect of its kind, but that the walls are planned as fortifications with a degree of skill that excites the highest admiration of the military engineer.

The oldest known building in Peru is that called the house of Manco Capac, which stands on an island in the lake of Titicaca. It is built of rather small irregular polygonal blocks of stones; is curvilinear in plan and has small rude towers. The interior is divided into small square rooms, which are lighted only from the doorways. Not far from it is a later and less rude building of two stories, known as the House of the Virgins of the Sun. It is nearly square in plan, and is divided into twelve small square rooms on each story, those on the ground-floor being lighted by the doorways, and those above mostly by very narrow windows, but some are without any opening or light.

The most extensive Peruvian buildings occur in the table-land of Cuzco, which was the most ancient seat of the monarchy of the Incas. There are also ancient remains within the boundaries of the present republic of Ecuador. Near the ridge called Chisinche, not far from the volcano Cotopaxi, are the ruins of a large building called the Palace of the Incas. It was a square, of which each side was about 30 yards long, and it had four doors. The interior was divided into eight apartments, three of which are still in tolerable preservation. Not far from the mountain-pass of Assuay is a building called Ingappilca, or the Fortress of Cañar, consisting of a wall of very large stones, about 5 or 6 yards high; it has a regular oval form, of which the greatest axis is nearly 40 feet long.

In the ruins of the town of Chulcanas, in the department of Truxillo, near the boundary-line between Peru and Ecuador, Humboldt had an opportunity of observing the construction of the private buildings of the Peruvians, and he observes that they consist of one room only, and that probably the door opened into a court-yard.

Of the ancient Peruvian tombs, the majority are square in plan: have the burial-place in the basement; a small chamber above, the door to which, at some height from the ground, is the only opening into the tomb; and flat roofs. Some of the tombs appear to have had domicular roofs; and remains of a few tombs occur circular in plan.

(Humboldt, *Vues des Cordillères et Monuments des Peuples Indigènes;* Rivero e Tschudi, *Antiguedades Peruanas;* Gailhabaud, *Monumens Anciens et Modernes:* Fergusson, *Handbook of Architecture.*)

PERUVIC ACID. A colourless, inodorous, crystalline acid, formed by acting upon guanine by a mixture of chlorate of potash and hydrochloric acid.

PERUVIN. [Styrone.]

PESTILENCE is a general term applied to those diseases of an epidemic character which affect large masses of a population, and are remarkable for their destruction of human life. The two forms of disease to which this term is most frequently applied, are plague and Asiatic cholera.

Plague is a disease of so fatal and malignant a nature, that to this very circumstance it probably owes its nomenclature. The nosological definition of this disease by Dr. Cullen is perhaps as correct as can be given in few words:—"A typhus fever, in the highest degree contagious, and accompanied with extreme debility. On an uncertain day of the disease, there is an eruption of buboes or carbuncles." Dr. Patrick Russell, who practised at Aleppo during the plague of 1760-1-2, informs us that its progress at its commencement is much the same in the several parts of the Levant as in the cities of Europe. It advances slowly, fluctuating perhaps for two or three weeks; and although at that period it generally proves fatal, yet it is often unattended by its characteristic eruptions. Indeed the cases in which the eruption is wanting constitute the most rapidly fatal type of the disease. The general derangement of the system which ushers in an attack of the plague, is much like that which commences the course of ordinary fever. A sense of cold, with some shivering, which is soon followed by heat and acceleration of the pulse, with giddiness, headache, depression of strength and spirits, white tongue, vomiting or diarrhœa, and great oppression about the præcordia, are among the first symptoms of the disease. These are succeeded by a burning pain about the pit of the stomach; by a peculiar muddiness of the eyes; by coma, delirium, and other affections of the sensorium, which terminate by death in some cases on the second or third day, before the pathognomic symptoms, buboes and carbuncles, have appeared. In other cases these last mentioned symptoms are present, together with purple spots and ecchymoses, which belong to the plague in common with other malignant fevers. Though these are the ordinary symptoms of plague, they are not invariably observed in the same individual; but many varieties occur, which chiefly have reference to the greater or less virulence of the disease, and the absence or presence of some particular symptoms. Thus, we are informed by Sydenham that in the infancy of the great plague of London scarce a day passed but some of those who were seized with it died suddenly in the streets, without having had any previous sickness; the purple spots, which denote immediate death, coming out all over the body, even when persons were abroad about their business; whereas after it had continued for some time, it destroyed none, unless a fever and other symptoms had preceded. Dr. Russell describes six classes or varieties of plague, in some of which the fever appears to have been very violent, while in others it was proportionally mild. The most destructive forms of the disease, according to this author, were marked by severe febrile symptoms; and the infected of this class seldom or never had buboes or carbuncles. The bubo however was the most frequent concomitant afterwards; carbuncles, on the contrary, were remarked in one-third of the infected only, and were seldom observed at Aleppo earlier than the month of May, near three months after the disease began to spread. The carbuncle increased in the summer, was less common in the autumn, and very rarely was observed in the winter. The absence of bubo and carbuncle at the commencement of the plague has been one of the grounds of contention among writers as to the real nature of the disease. Diemerbroech and some others assure us that no one symptom is pathognomonic of plague, and Dr. Russell concludes that "the plague, under a form of all others the most destructive, exists without its characteristic symptoms, can admit of no doubt." From all the evidence upon this subject that we have been able to collect, it plainly appears that authors are by no means agreed on the existence of the plague as a distinct disease. The symptoms, morbid changes, history, and mode of propagation of plague, bear so close a resemblance to those of the malignant typhus of this country, that it is difficult to regard them otherwise than as types of the same disease. This opinion is strengthened by the authority of Dr. Mackenzie, who resided thirty years at Constantinople. "The annual pestilential fever of that place," he observes, "very much resembles that of our gaols and crowded hospitals, and is only called plague when attended with buboes and carbuncles." Sir John Pringle too observes, "that though the hospital or gaol fever may differ in species from the true plague, yet it may be accounted of the same genus, as it seems to proceed from a like cause, and is attended with similar symptoms." The buboes which characterise plague consist of inflammatory swellings of the glands in the groin and armpits; the parotid, maxillary, and cervical glands sometimes, but less frequently, become affected. These buboes may either suppurate or gradually disperse: when suppuration occurs, it is seldom till the fever has begun to abate, and is manifestly on the decline, as about the eighth or ninth day. Carbuncles consist of inflamed pustules, or angry pimples, which, instead of suppurating, frequently terminate in mortification. They may be seated on any part of the body.

The morbid changes that are met with in the bodies of those who die from plague are very similar to what we find in typhus, yellow fever, and in the carcases of animals that have died in consequence of a putrid matter injected into their veins. The vessels of the brain and its membranes are gorged with a dark coloured blood; the lungs and liver present traces of inflammation or of gangrene; patches of inflammation and ulceration are met with in the stomach and intestines; the heart is of a pale red colour, easily torn, and full of black blood, which, according to M. Magendie, never coagulates. These changes however are not always found, and the same absence of appreciable organic lesion is sometimes observed in typhus and other diseases which prove rapidly fatal. No age, sex, or profession appears to enjoy an immunity from plague, nor does one attack secure the individual from future infection; but it has been observed that old persons, women, and children suffer less frequently and severely from its attacks than robust adults. Some persons also, who exercise particular trades, as knackers, tanners, water-carriers, bakers, and oilmen, seem to share this advantage; while smiths and cooks were noticed, during the campaign in Egypt, to be more particularly liable to it. One law appears to be universal in all plagues, namely, that the poor are the first and chief sufferers. In Grand Cairo, Constantinople, and Aleppo, it is in the low, crowded, and filthy parts of those cities, occupied by the poorest people, that the plague commits its greatest ravages. The celebrated plague of Marseille, in the year 1720, first appeared in a part of the city noted for the sordid filth, crowded state, and wretchedness of the poor inhabitants. This was likewise true of London, where, from the same circumstance, it obtained the appellation of the Poor's Plague. Like many other diseases, plague is observed in two forms: first, as an indigenous and local disease, peculiar to the inhabitants of certain countries, and from which they are never entirely free; and secondly, as a raging and fatal epidemic, not confined to its original seat, although exhibiting itself there in its most intense forms. It is the epidemic variety of this fatal malady that has engrossed so much attention from the earliest times down to the present; and we shall therefore briefly pass in review some of the principal circumstances which attend its origin, progress, and termination.

It has been observed that nearly all plagues have been preceded by certain natural signs, and by a greater mortality from malignant diseases generally than at other times. Among these precursory signals, great and sudden atmospheric vicissitudes have been noted. Livy (v. 13) attributes the origin of a pestilence to this cause. "The year was remarkable," he observes, "for a cold and snowy winter, so that the roads were impassable and the Tiber completely frozen. This deplorable winter, whether it was from the unseasonable state of the air, which suddenly changed to an opposite state, or from some other cause, was succeeded by intense heat, pestilential and destructive to all kinds of animals." But in the great plague of Athens, of which Thucydides has given so minute a description (ii. 48, &c.), he observes that the year of the plague was particularly free from all other diseases; and he mentions nothing unusual as having occurred in preceding years. The city however was then greatly over-crowded with inhabitants, a great part of the population having taken refuge within the walls of Athens (ii. 16), in consequence of the war. [Pericles, Biog. Div.] Russell informs us that the winter of 1756–7, which preceded the petechial fever of 1758 at Aleppo, and the plague of 1759–60-1-2 in different parts of Syria, was excessively severe. Olive-trees which had withstood the weather for fifty years were killed. In the following summer a dearth ensued from the failure of the crops, and so severe a famine, that parents devoured their own children, and the poor from the mountains offered their wives for sale in the markets to buy food. The connection between famine and pestilence has been noticed in all ages of the world. An enormous increase of insects has frequently been observed to precede a pestilence. We are informed by Short, that in 1612 Constantinople was infested with crowds of grasshoppers of great size that devoured every green thing, and the next year (1613) the plague carried off 200,000 inhabitants of that city. In 1612, swarms of locusts laid waste the vegetable kingdom in Provence; and in 1613 the plague appeared in different parts of France. Locusts and pestilence are frequently mentioned together in the sacred writings; and we find that the plagues of Egypt exhibited a series of phenomena, rising in progression from corruption of the rivers and fountains, swarms of insects, murrain among cattle, thunder and thick darkness, and a tribe of inferior diseases, to that fatal pestilence which swept away the first-born of the Egyptians. In fine, dearth or unwholesome provisions, pestilence among cattle, great abundance of insects, absence or death of birds, blight and mildew, appear, with few exceptions, to have separately or conjointly preceded or attended all such calamities. Plague is usually preceded by other diseases which occasion great mortality. Lord Bacon has observed that "the lesser infections of small-pox, purple fever, agues, &c., in the preceding summer and hovering all winter, do portend a great pestilence the summer following; for putrefaction rises not to its height at once;" and Dr. Mead states, as a general fact, that fevers of extraordinary malignity are the usual forerunners of plague. Indeed nearly all the most remarkable plagues of the last two centuries have been preceded by malignant fevers. The increased number of deaths from this source will be seen by an examination of the London Bills of Mortality at the three last plague epochs in this country, an abstract from which we here present, showing the number of deaths from other diseases besides the plague, in 1625, 1636, and 1665, with that of the year before and after respectively:—

Years.	Common Diseases.	Plague.
1624	12,199	11
1625	18,848	35,417
1626	7,400	134
1635	10,651	..
1636	12,959	10,400
1637	8,681	3,082
1664	18,291	6
1665	28,710	68,596
1666	10,840	1,998

The season of the year in which plague commits its greatest ravages differs in different countries. In Europe it has invariably raged most violently and fatally in the summer and autumnal months, especially in September. Thus, in the plague of London in 1665, the deaths from the plague were: in June, 590; in July, 4129; in August, 20,046; in September, 26,230; in October, 14,373; in November, 3449; and in December they were under 1000. In Egypt it commences in the autumn, and prevails till the beginning of June, and the vernal equinox is the period of the greatest fatality. Extremes of heat and cold generally check, and not unfrequently entirely arrest its progress. In tropical climates the disease is unknown, and in Egypt, according to Alpinus, to whatever degree pestilence may be raging, as soon as the sun enters Cancer it entirely ceases. The cold weather of northern climates has been observed to check the ravages of plague; and in these countries, when it has broken out in the autumn, its course has been arrested during the winter months. With respect to the progress and termination of plague, the disease appears to be subject to the same laws as regulate the course and termination of other epidemics: it is most fatal at its first outbreak, and becomes less virulent as it increases in extent. The increased mortality which occurs during the advance of plague, and which we have before shown to be at its height in the month of September, arises from the increased extension, and not from the greater malignancy of the disease. With its progress and decline there has usually been observed a progressive increase and decrease in the whole train of diseases, and those which had immediately preceded plague, on its decline reappeared. The former fact will be seen by a reference to the table we have given above.

The causes of plague have been referred by some to a vitiated atmosphere, engendered by epidemic and endemic causes, and wholly independent of contagion; while others have attributed it solely to the latter influence. The truth probably lies between these extremes, and we have little doubt, from an examination of the evidence on both sides of the question, that both these causes do occasionally operate in the propagation of plague. As the foundation of quarantine establishments rests entirely on the supposition of the contagious nature of plague, we shall examine how far this can be supported by a reference to facts. It is asserted by the contagionists that plague is transferred from individual to individual in all the ascertained modes in which diseases are thus communicated—by contact, by inoculation with the matter of buboes, through the atmosphere, and by fomites. According to them, its appearance in Western Europe has been always owing to imported contagion; and where strict isolation from all infected individuals and articles has been observed, there it has never appeared. It is admitted however by several, among whom may be mentioned the respected names of Sydenham, Russell, and Mead, that a peculiar atmospheric condition is essential to the spread of plague; yet they maintain that this is inadequate to its production without importation by fomites, or the arrival of a diseased person from an infected district. In support of this opinion, they refer to the histories of the different plagues that have visited Europe, and above all to that which ravaged Marseille in the year 1720. Its introduction into this city was traced to the arrival of three ships or lazarettos, which, by some means or other, for we learn not how, communicated the disease to a woman living in the Rue de l'Escale. This person being received into the Hôtel Dieu, two of the nurses who assisted at her reception, and the matron who changed the linen, were taken ill the next day, and died after a few hours. In a short time it destroyed physicians, surgeons, apothecaries, confessors, and all the other officers and servants, with the whole of the poor in the hospital, including above 300 foundlings. The priests and monks who attended the infected suffered in the same manner as the medical assistants: and lastly, of 230 galley-slaves, employed in going into the infected houses and burying the dead, 220 perished in the space of ten or twelve days. Dr. Bancroft justly observes that "it is fortunate for mankind that the communication of the contagion of the plague depends upon the co-operation of so many favourable circumstances, and particularly upon that of a suitable temperature, and of certain aptitudes and susceptibilities in the human subject; for without such requisites, or such obstacles to its propagation, the earth might have long since become desolate."

Those who contend for the non-contagiousness of plague, and therefore for the abolition of the quarantine laws, maintain that these laws, however strictly enforced, have not succeeded in shutting out the plague from pestilential districts: and that countries not possessing indigenous sources of pestilence are not visited with this disease, although unprotected by quarantine establishments. They likewise adduce numerous instances of persons in constant communication with plague patients, and even wearing their clothes, escaping the disease. Odessa has one of the best organised quarantine establishments in the world; yet not long ago the plague broke out in it, entered the town, destroyed a number of inhabitants, and ceased at a particular season. In 1835 the harem of the pasha of Egypt consisted of about 300 persons; but notwithstanding the severest cordon, the plague entered, and seven died within. The cordon was composed of 500 men, who were in constant contact with the town, where the disease was raging violently; of these only three died, so that the proportion of those who perished within to those without was nearly as 4 to 1. The plague of 1665, which ravaged most parts of this kingdom, never visited Oxford, although the terms were kept there, and the court and both houses of parliament were held there; a close correspondence too was maintained between this city and the metropolis, where it was raging. The Persians, although their country is every year surrounded by the plague, seldom suffer anything by it themselves. "The Turks and Moors," says Bruce, "immediately after St. John's day, expose in the market-places the clothes of the many thousands that have died of the plague during its late continuance; and though these consist of furs, cotton, silk, and woollen cloths, which are stuffs the most retentive of the infection, no accident happens to those who wear them." Clot Bey, who while at the head of the medical department in Egypt, treated thousands of cases, says, that removed from malaria or miasm, he has never known the plague to be communicated by contact. He has twice inoculated himself with the pus and blood of those affected with plague, but without producing the disease. Others, however, who have performed this operation on themselves, have contracted the disease and died.

This fully agrees with the evidence that was given before a select committee of the House of Commons, on the contagion of plague, in 1819. It appears from the Custom-house returns, that none of the expurgators of goods in Great Britain, at the quarantine establishments, have ever taken the plague. What then are we to regard as the cause of pestilence, and whence is it to be sought? Undoubtedly in the miasm of pestiferous soils; or of crowded, ill-ventilated, and filthy localities. When plague has at any time become epidemic, these are the spots in which it has first planted itself, and in which it has committed the greatest devastation. Notwithstanding the obviousness of this fact, it is a remarkable circumstance in connection with the history of plague, that no people in the world have been willing to acknowledge their own country to be the first or indigenous seat of pestilence. The doctrine that it is imported and not indigenous, is as prevalent in Turkey as it is in Egypt. The Egyptian Levantines insist that it has never been an Egyptian endemic, but has been imported by travellers or goods; while the Turks contend that it is from Egypt. In the eloquent language of Dr. Hancock, "Egypt disowns it; Ethiopia has no such progeny; Syria is too genial for its production; and Constantinople harbours it through neglect or sufferance. As to the north, how could the temperate climate of Britain generate a principle so terribly destructive?" Facts, however, are too numerous and weighty to allow us a moment's hesitation on this point. Wherever civilisation has advanced, there plague has receded, till it is now only to be found lurking among the swamps of Egypt or revelling in the filth of Constantinople. It is the spring, we have seen, that is so fatal to the Egyptians, about which time south winds prevail, loaded with putrid emanations from animal and vegetable substances in the lakes formed by the retiring waters of the Nile. In June, the wind is in the north, passing over the Mediterranean, and this is the most healthy and salubrious season. In Constantinople, the month of August is most fatal, and this is the season of the year when decomposition goes on with greatest rapidity. The exemption of the city of Oxford, in the plague of 1665, is a strong proof of the correctness of these opinions. The following words from Quincy are much to the purpose: "Dr. Plott observes, the reason why Oxford is now much more healthful than formerly, to be, the enlargement of the city, whereby the inhabitants, who are not proportionately increased, are not so close crowded together; and the care of the magistrates in keeping the streets clear from filth. For 'formerly,' he says, 'they used to kill all manner of cattle within the walls, and suffer their dung and offals to lie in the streets. Moreover about those times, the Isis and Cherwell, through the carelessness of the townsmen, being filled with mud, and the common-sewers by such means stopped, did cause the ascent of malignant vapours whenever there happened to be a flood. But since that, by the care and at the charge of Richard Fox, bishop of Winchester, in the year 1517, those rivers were cleansed, and more trenches cut for the water's free passage, the town has continued in a very healthful condition, and in a particular manner so free from pestilential diseases, that the sickness in 1665, which raged in most parts of the kingdom, never visited any person there, although the terms were there kept, and the court and both houses of parliament did there reside.' " Now what was done in Oxford, as early as 1517, to remedy its unhealthiness, has since been done in all the principal cities of this country and on the Continent. Accordingly we find that the plague has not visited us since 1665. Holland, which has no system of quarantine, has experienced an exemption corresponding to that of our own country. Paris has not been attacked since 1668, and a century has elapsed since the plague of Marseille.

Treatment of Plague.—The preventive treatment of plague will be gathered from what we have said respecting the causes of this disease, and the most effectual barriers that can be opposed to its future introduction into Europe, are, to adopt again the language of Dr. Hancock, "the barrier of cleanliness in our towns and villages against filth and crowded habitations; the barrier of Christian charity towards our poor against famine and distress; the barrier of peace against the desolating evils of war; and the barrier of industry against the vice of sloth." With regard to remedial measures, it appears little can be done towards arresting the progress of plague after it has once declared itself in an individual. Our efforts therefore are limited to removing the patient from those sources of miasm which give origin to his disease, and in placing him in those conditions which are most favourable for his recovery. Free exposure to fresh air, supporting the strength, and regulating the secretions, are the only means which promise much chance of success. When this plan is adopted, we have the authority of our latest writers on this subject for declaring that the mortality of the disease may be considerably diminished. Thirty per cent. only, of those attacked, die under this mode of treatment; while in the lazaretto at Alexandria, 90 per cent. died in 1833, and 77 in 1836. With respect to the management of buboes and carbuncles, they must be treated in the way which is found efficacious in their removal when uncomplicated with plague, and if by these means we are unable to effect their dispersion, suppuration may be promoted by the employment of emollient cataplasms or any other mild stimulant.

In the following chronological table of some of the principal plagues upon record, we have purposely omitted the mention of many which, although described under that name, are obviously a different disease; even among those we have selected, the vagueness with which the symptoms of some are described, leave us in doubt whether the disease was the same as that which at present goes under the name of plague:—

B.C.
1491. The plague of Egypt. (Exodus, xii.)
1490. „ in the Wilderness. (Numbers, xi.)
1250. „ of Ægina. (Ovid's 'Metam.,' lib. vii. 523.)
1190. „ in the Grecian camp at the siege of Troy. (Homer's 'Iliad,' book. i.)
1141. „ among the Philistines. (1 Sam., v. vi.)
1017. „ in Canaan. (2 Sam., xxiv.)
738. „ of Rome. (Plutarch's 'Life of Romulus.')
464. „ „ (Livy, iii. 6; Dion. Halicar., lib. x.)
454. „ „ (Livy, iii. 32.)
437. „ „ (Livy, iv. 21, 25.)
430. „ of Athens. (Thucydides, ii. 48, &c.)
404. „ of Carthage. (Justin, xix. 2; Diod. Sic. xiii., xiv.)
366. „ of Rome. (Livy, vii. 1; Short, 'On Air.')
296. „ „ (Livy, x. 31, &c.; Orosius, iii. 21.)
213. In the Carthaginian and Roman armies before Syracuse. (Livy, xxv. 26.)
182–177. Rome and all Italy. (Livy, xli. 21.)
126. Numidia and Carthage. (Livy, 'Epit.,' 60; Orosius, lib. 5.)

A.D.
68. Rome. (Tacitus, 'Annals,' xv. 47; xvi. 13; Orosius, lib. vii.; 'Univers. Hist.,' vol. xiv., 139.)
167, and few following years. Rome, and a large part of the known world. (Am. Marcellinus, lib. xxiii.; Echard's 'Rom. Hist.,' vol. ii., 315, &c.)
187. Rome and Italy. (Herodian, lib. i.)
252–270. Rome and a large portion of the globe. (Zonaras, lib. xii.; Gibbon, vol. i. 10.)
407. Most of Europe, Asia, and Africa. (Nicephorus, xiii. 6, 36; Magdeburg, cent. v. 13.)
542–590. A plague raging with intermissions, in most parts of the world. (Niceph., xvii. 18; 'Eccles. Hist.,' lib. iv. 29.)
1345–1350. Europe, and most parts of the world. (Boccaccio 'Decameron,' 'Prima Giornata;' Muratori, iii. 588, &c.; Villari; Short 'On Air,' vol. i., 165; 'Univ. Hist.' vol. xxxii.)
1562 and 1563, London and most of the principal cities of Europe. (Short, vol. i.; Thuanus.)
1575 and 1576. Italy and most parts of Europe. (Thuanus, lib. lxii.; Short, vol. i.; Mercurialis, 'On the Plague of Venice.')
1580 and 1581. Grand Cairo and different parts of France. (Thuanus.)
1600 and 1603. London and various parts of Europe. (Maitland's 'Hist. of London;' Mignot, 'Hist. of the Turkish Empire,' p. 256.)
1611 and 1613. Constantinople, France. (Riverius, lib. xvii.; Short, vol. i.; Mignot.)
1625. London and various parts of Europe. (Short.)
1635 and 1636. London, Nimeguen, and several other places in Europe. (Diemerbroeck, 'Tractatus de Peste.')
1655 and 1656. Most of Europe. Naples suffered very severely, three-fourths of its inhabitants having perished. 'Univ. Hist.,' vol. xxviii., 318.
1663–65. London and most parts of England and Holland. (Sydenham; 'City Remembrancer;' Hodge's 'Loimologia.')
1702–11. North of Europe. (Described, especially as it appeared in Danzig, by Dr. Gottwald; and 'Univ. Hist.,' vol. xxxv.)
1720. Of Marseille. (Chicoyneau's 'Traité de la Peste;' Bertrand's 'Relation Hist. de la Peste de Marseilles.')
1743. Aleppo. (Its 'Natural History,' by Dr. Alex. Russell.)
1751. Constantinople. (Chenier's 'Morocco,' vol. ii., 275.)
1760–62. Aleppo, Jerusalem, and Damascus. ('A Treatise of the Plague, &c.,' by Dr. Patrick Russell.)
1770 and 1771. Constantinople, Poland, and Russia. (Described, especially as it appeared in Moscow, by Mertens; and 'Ann. Regist.,' 1772, p. 155.)
1783–85. Egypt, Dalmatia, Constantinople, &c. (Volney's 'Travels, vol. i., 192; 'Courant,' October 28, 1783, and October 27, 1785.)
1799. In the French army in Egypt. (Sotira, 'Mémoire sur la Peste observée en Egypte pendant la Sejour de l'Armée d'Orient dans cette Contrée;' Baron Larrey, 'Description d'Egypte, &c.')

For further accounts of the plague, as it has appeared more recently, see Tully's 'Hist. of the Plague in the Islands of Malta, Gozo, Corfu, Cephalonia, &c.,' 1821: also Dr. Bowring's 'Observations on the Oriental Plague and on Quarantine, &c.,' 1838; and Dr. Andrew White, 'On Plague and Quarantine,' 1846.

Pestilential, Epidemic, or Asiatic Cholera is a disease not less fatal than that described in the preceding article; and in its endemic origin, its occcasional epidemic eruptions, its selection of victims, and the localities which it ravages, it bears a striking resemblance to plague. Its essential character is, however, perfectly distinct, as will be seen by the following account of the symptoms of cholera. The disease has two well-marked stages: the cold or choleraic, called also the stage of collapse; and the hot or febrile stage, or that in which reaction takes place. The first is generally preceded by certain premonitory symptoms, among the most prominent of which is diarrhœa, accompanied usually with languor and some degree of nausea; the dejections are fæcal and bilious, and often very copious. The commencement of the purging may precede the accession of the febrile stage for several days, or only a few hours may elapse. It is important not to think lightly of this disorder during the prevalence of epidemic cholera, for many a life might have been preserved if timely warning had been taken, and appropriate treatment adopted for removing it, before the accession of the symptoms about to be described.

Symptoms of the cold stage.—The time of its invasion is, in the majority of instances, from two to four o'clock in the morning. The patient is attacked with uneasiness of the stomach, to which speedily succeed vomiting and purging of a watery, colourless, and inodorous fluid, similar to barley-water, or more frequently *to rice-water;* sometimes it is like milk, and occasionally yellowish; but the 'conjee-stools,' as they are termed, which consist of albuminous flakes floating in serum, or discharges of pure serum, are of the most frequent occurrence. These discharges are attended with severe cramps in the extremities, especially in the calves of the legs, and are succeeded by exhaustion, giddiness, and sinking of the pulse; the pulse is small, weak, and accelerated; and after a certain interval becomes imperceptible. The skin is cold from the commencement; and as the disease advances, it becomes gradually colder, and is covered either with a profuse sweat or a clammy moisture. The temperature of the whole body is lower than natural. The features are shrunk and anxious: there is restlessness and agitation, with great thirst, heartburn, and hurried respiration. Notwithstanding the coldness of the body externally, the patient complains of heat, and throws off his bed-clothes. As the cold increases, the skin frequently becomes blue; the eyes, which are dull and suffused, seem drawn into and fixed at the bottom of their sockets; the tongue is cold but moist; the voice is feeble, hollow, hoarse, and interrupted; but the mental functions remain undisturbed to the last. At this advanced period the collapse is complete, the respiration very slow, and the patient, who suffers little or no pain, presents the appearance of a person who has been dead for some time. The urine is usually suppressed throughout the whole of this stage; but the dejections, becoming thinner and thinner, continue to the last. Some patients, although blue, cold, and pulseless, have sufficient strength to go about; many, however, die of exhaustion before all these symptoms have declared themselves. In the majority of cases the spasmodic symptoms are first observed, and afterwards the collapse; the former are characterised by pain, evacuations, and moans; the second, by the suppression of voice, urine, and heat. If, however, the patient get over the cold stage, that of reaction commences. The coldness and blueness gradually disappear; the pulse returns, increasing in force and frequency; to the pale or blue cheek succeeds the flush; the eye brightens; the tongue, which was of a dirty white, becomes cleaner and dry; vomitings are less frequent, but diarrhœa continues; and there is some tenderness of the abdomen, with thirst, great disgust of food, and intense headache. The urine, however, is secreted; and if all goes on well, at the end of two or three days the features assume their usual expression; the stools are less frequent and more natural; the strength and appetite begin to return; the pulse resumes its ordinary character; and the patient is convalescent. Several varieties occur in the duration and intensity of cholera, and complications are sometimes produced of a character not less fatal than the disease itself. We are informed by M. Dalmas, that soldiers attacked in full march will retire from the ranks, lay down their arms by the roadside, and expire in two hours. During the prevalence of the last epidemic in India, several instances were heard of at Houbley and other places in that country, of natives being struck with the disease while walking in the open air; they fell down, retched a little, complained of vertigo, deafness, and blindness, and expired in a few minutes. This rapidly fatal form of cholera has not been observed in this country. The most severe cases that we have met with generally lasted five or six hours; but the average duration of the fatal cases, when they did not terminate in consecutive fever, was from twelve to fourteen hours. When reaction was established, and fever supervened, the duration of fatal cases was from four to ten days. As a general rule to guide us in forming a prognosis, it may be stated that the more complete is the collapse, the greater is the danger; and if the patient survive it, the more violent and malignant is the subsequent fever. The cases in which spasms and vomiting are most violent are by no means the most dangerous.

Morbid Anatomy of Cholera.—Dissection presents us with nothing satisfactory by which we can judge of the nature of the disease. There is general venous congestion of all the important organs in the body; but it is rare that any traces of inflammation are discovered. The gall-bladder is mostly distended with bile, and its ducts are constricted. In the stomach and intestines is found either a transparent or a turbid serous fluid, mixed with a white opaque substance in the form of flakes, and similar in all respects to the matters ejected during life. The mucous membrane lining the intestinal canal is most frequently of a pale white colour, and somewhat more soft and pulpy than in its natural condition; but occasionally some degree of vascularity is observed. The urinary bladder is empty and contracted. With respect to the blood, it is found to be more viscid, and darker coloured than natural, which arises from a deficiency of its saline and watery components, and a relative increase of its solid constituents. In 1000 parts of serum, Dr. O'Shaughnessy found 133 of albumen, whereas healthy serum contains only 78 parts. On comparing the blood with the matter found in the intestines, it is manifest that the latter contains all the ingredients of the blood, except the red globules; and that the aqueous and saline parts pass out of the circulation more rapidly than the albuminous. This state of the blood explains the congestion more especially in the lungs, and accounts for the derangement of the functions of the respiratory system.

History and Statistics of Cholera.—There appears to be little doubt that pestilential cholera has from time immemorial visited the various populations of the world. It was described by Sydenham in the 17th century, and various outbreaks are recorded during the 18th century. It however excited the greatest attention in Europe during the second quarter of the present century. That this form of cholera is more or less indigenous in Europe is the opinion of most medical writers at the present day. The circumstances which cause the sporadic form to assume a contagious and epidemic character are not well understood. During the present century Europe has sustained three outbreaks of this disease. The first in 1828-29, 30 and 31; the second in 1847-48, and 49; the third in 1852-3, and 4. The history of the first outbreak is as follows:—It originated in the district of Nuddeah and in some other parts of the delta of the Ganges, about the end of May or the beginning of June, 1817. During that year it did not extend beyond the territory of Lower Bengal; but in 1818 and the early part of 1819 it diffused itself throughout the extreme length and breadth of the Indian peninsula, yet leaving untouched many districts placed between its lines of movement. Its progress along the lines selected was wonderfully uniform, being, for some successive months, at the rate of about one degree in a month. As early as 1818, it extended itself beyond the boundaries of Hindustan into the Birmese empire and other parts of Eastern Asia, and making gradual progress through these countries, reached China in 1820, and in the following year visited the numerous and populous islands of the Indian Archipelago. The Isle of France suffered its invasion in 1819, and some cases occurred in the same year at one point in Bourbon. In 1821 it extended along the shores of the Persian Gulf, and, during this and the following year, spread through parts of Arabia, Persia, and Syria, and closely threatened Europe. It appeared in the Russian territories in 1823, at Teflis, Orenburg, and Astrakan; but its farther northern and western progress was stopped for a time. It however reappeared in Orenburg in 1828, and again in 1829, and in 1830 advanced through the southern provinces of the Russian empire, till it reached Moscow on the 28th of September of that year, and Petersburg the year following. Warsaw was attacked in March, 1831; Danzig in May; Berlin, in August; Hamburg and Sunderland in October; and London and Paris in 1832. At the end of 1833 it had reached Mexico and several other parts of America. We see that the course of the epidemic was principally from east to west, and it was observed that prior to its appearance in many countries, and during its continuance, easterly winds were uncommonly prevalent; but most accurate and extensive meteorological observations, made daily during the continuance of the disease, prove that neither variations of temperature, fluctuations of the barometer, change of wind, nor the prevalence nor absence of moisture, affect in the slightest degree its duration or intensity. Bowel complaints appear to have preceded the cholera in most places, and to have continued for some months after its cessation. In many localities the disease existed only for a few weeks, while in others it lingered for several months. In the first case, the mortality was invariably high; in the last, the malignancy of the disease generally diminished as its stay was prolonged. Into whatever country or town the disease advanced, its first and most deadly fury was expended upon the poorest and most miserable of the population, and upon those who inhabited crowded districts, or low humid localities bordering on a port or river. Among this class of individuals whole families were sometimes cut off by it; indeed it is a peculiar feature of epidemic cholera that its ravages are confined almost exclusively to the poor. When the disease has appeared in a family occupying a station in life above the labouring class, we have the authority of Dr. Brown for declaring that in every case it has been confined to the individual first attacked, and has not in any instance spread to the other members of the family. The mortality from this disease is very great; but it varies somewhat in different countries and at different stages of its epidemic career. During its early prevalence in India, in 1817 and 1818, we learn, from the 'Report to the Medical Board at Bombay,' that there is reason to believe that of 1294 cases which received no medical assistance, every individual perished; and it is added, that it is not ascertained that any person has recovered to whom medicine had not been administered. This appalling statement however is without parallel, and it is gratifying to know that where the premonitory symptoms have been combated by early and judicious treatment, the mortality has always been diminished. This is strikingly exemplified by the statistical records kept at our different military stations in various parts of the world. In all situations and under all modes of treatment, about one in two died of the cases in civil, and one in three of those in the military hospitals; a result doubtless to be attributed to the strict surveillance exercised over the troops, by which nearly one-half of the cases among them were noticed in the premonitory stage, and consequently could be treated with a greater prospect of success than those in the civil hospitals, where the great majority of the patients were far advanced in the disease before they applied for medical aid. Of the severe cases however the mortality is probably nearly the same in all, being about 60 per cent. One of the most extraordinary features of this epidemic, observes Major Tulloch, is that the proportion of deaths to the number attacked has been very nearly alike in all the military commands of which the medical records have been investigated: for instance—In the United Kingdom, the deaths were 1 in 3¼; in Gibraltar, 1 in 3½; in Nova Scotia, 1 in 3⅓; in Canada, 1 in 3; in Honduras, 1 in 3; in the Mauritius, 1 in 8⅓. The Mauritius appears to be the only exception to this; so that either the epidemic was less severe in its character, or the remedies employed were more successful.

The influence of age on the mortality by this disease among the troops of the line serving in Canada is exemplified in the following table:—

Age.	Ratio of Deaths at each Age, per 1000 of strength by Epidemic Cholera.
Under 18	—
18 to 25	15·5
25 to 33	23·
33 to 40	36·6
40 to 50	70·6

It appears from the authority to which we are indebted for the foregoing table, that females were attacked in very nearly the same proportion as males, but that the cases proved more generally fatal. Children were in a great measure exempt, though, when attacked, they rapidly sunk under it. The greater mortality of the disease in females has also been observed in this country. Dr. Ogden informs us that of 145 fatal cases of cholera at Sunderland, 63 were males and 82 females. The information which we possess on the relative mortality of the disease in the different races of mankind is rather meagre. The native Indians of North America suffered from it in an equal degree with the white population; and the same was observed with regard to the Sepoys in our Indian army. In the Mauritius, whose population in 1831 was 90,000, of which 25,000 were whites and the rest coloured, the total number of deaths recorded in the civil and military hospitals was 1327. Of these 168 were whites, 162 coloured, and 997 blacks, principally negroes, who seemed peculiarly subject to the disease. At this date, more than 2000 out of 4300 slaves belonging to government were cut off by it, and of those belonging to the planters nearly as many.

The disease as it appeared in Europe in the two last outbreaks presented no new features. There was the same great mortality at the onset. It travelled from city to city in the same manner and gradually disappeared. It broke out in England in 1848, and was present in London in 1849. It subsided and again appeared in 1853, and in London in 1854. Since that time it has gradually subsided, and no great epidemic has occurred in Europe since.

The number of persons attacked in a community by cholera has varied very considerably. In no instance has a whole population been attacked during an outbreak. In the marching corps of our army the number attacked has been from 17 to 330 for 1000 men. Moreau de Jonnès has given the following estimate for the numbers attacked in the countries of Europe.

France	1 in 300	Belgium	1 in 120
Russia	1 in 20	Great Britain and Ireland	1 in 131
Austria	1 in 30	Holland	1 in 144
Poland	1 in 32	Germany	1 in 700
Prussia	1 in 100		

Causes of Cholera.—That the whole series of phenomena results from the action of a morbific poison on the body, there can be no doubt; that this morbific matter is indigenous to some countries, and apparently has its origin in certain peculiar conditions of the soil, is supposed to be true from the effects which we find to be produced upon animal bodies living in these districts. But why the miasm arising from the overflow of the Nile should produce plague; that of the Ganges, cholera; that of the parts situated in the tropics, yellow fever; or our own marshes, simple intermittent—we are entirely ignorant; nor can we, in the present state of our knowledge, at all account for the epidemic spread of some of these endemic diseases.

Notwithstanding the extensive knowledge acquired from the recent outbreaks of the disease in Europe, no consistent theory of its cause has been proposed. Whilst its history would seem to point out the production of a poison in the interior of Asia, which was gradually conveyed to other parts of the world, there is not wanting evidence to show that similar epidemics have occurred without any trace of such origin. It seems not impossible that, under certain meteorological or other external circumstances, the ordinary diarrhœa or cholera of a district may acquire a contagious character; that is, the body may generate a poisonous matter, which, being carried into an otherwise healthy system, may engender the disease. Such a contagious character is occasionally assumed by diseases which do not ordinarily present this character, as erysipelas and dysentery. The following summary of the various theories which have been entertained to account for the spread of cholera is given by Dr. Aitken, in his 'Science and Practice of Medicine':—

1. "That the disease spreads by an atmospheric influence, or epidemic constitution by a succession of local outbreaks, and that the particular localities affected are determined by certain 'localising conditions,' which are, first, all those well-known circumstances which render places insalubrious; and second, a susceptibility to the disease in the inhabitants of such places, produced by the habitual respiration of an impure atmosphere."

2. "That the cause of cholera is a morbific matter, which undergoes increase only within the human body, and is propagated by means of emanations from the bodies of the sick; in other words, simply by contagion."

3. "It is supposed that the poison of cholera is swallowed, and acts directly on the mucous membrane of the intestines, and is at the same time reproduced in the alimentary canal, and passes out much increased with the discharges; and that these discharges afterwards, in various ways, but chiefly by becoming mixed with the drinking waters in rivers and wells, reach the alimentary canals of other persons, and produce the like disease in them."

4. "Assuming that the cause of cholera is a morbific matter, or poison, it is supposed that it is reproduced only in the air, and within the bodies of those whom it affects, and that its diffusion is due to the agency of the atmosphere."

5. "It is supposed that the cholera poison is increased by a species of fermentation, or other mode of reproduction, in impure, damp, and stagnant air; and it is maintained that it nevertheless is distributed and diffused by means of human intercourse, it being carried in ships and other vehicles, and even in the clothes, especially in the foul clothes of vagrants, and the accumulated baggage of armies."

6. "It is assumed that the material causes of the disease may be increased and propagated in and by impure air, as well as in and by the human body."

Those who deny the existence of any specific poison, give the greatest prominence to meteorological conditions and the external circumstances that induce a predisposition to the disease. Those who admit the existence of a poison, cannot deny the controlling influences exercised by these agencies.

Although there is no evidence to connect all attacks of cholera with a particular state of the atmosphere, there is much evidence to show that cholera occurs, as a rule, with an increased temperature, and that, *cæteris paribus*, the higher the temperature the more virulent is the disease. During the first outbreak of cholera in Great Britain, the temperature of the preceding year had not only been unusually high, but the atmosphere, both inland and sea, was unusually stagnant, close, and hot. This state of the atmosphere was observed both in the second and third outbreaks. Mr. Glashier observes, that there was a misty condition of the atmosphere, and that the readings of the barometer were remarkably high; while in the two last a total absence of ozone was observed. In other parts of the world similar phenomena have been observed. Such states of the atmosphere are attended with a marked tendency to putrefactive change in organic substances, and the consequent diffusion of their products in the air.

But whilst these general conditions of the atmosphere have existed during an outbreak of cholera, the occurrence and spread of the disease has been determined by a variety of circumstances, which have acted as predisposing causes in individuals. Amongst the most active of these may be mentioned impure water, lowness of site of dwelling, and the emanations of animal and vegetable refuse.

The action of impure water is well illustrated in the history of the two epidemics occurring in London in 1849 and 1854. The district of Lambeth, in 1849, was supplied with water by two companies, the Lambeth and Vauxhall water companies, both deriving their water from the Thames at Battersea. In this year, the population which was supplied by those companies suffered equally from cholera. But when the cholera revisited London in 1854, the Lambeth company was obtaining a new supply of water higher up the river, at Thames Ditton, beyond the tidal action of the river. The consequence of this improved supply was very remarkable in its action on the predisposition of the inhabitants to take cholera; for although the Lambeth company supplied houses in the same streets, and over precisely the same character of population, as the Vauxhall company, it was found that the deaths from cholera in the latter population were as 7 to 1 of the former. In all respects the supply of water was the same, but that in the one case the company supplied a water more highly charged with organic impurities than in the other. A still more striking case, illustrative of the influence of impure water in the production of cholera, occurred in the district of Broad Street, Golden Square, St. James's, Westminster, in 1854. In the course of five or six days, from the 30th of August, not less than five hundred persons died of cholera out of a population of not more than four or five thousand. After a rigorous investigation, it was ascertained that the majority of those persons had partaken of water from the pump in Broad Street, which on examination was found to communicate with a cesspool in an adjoining house. ('Report on the Cholera Outbreak in the Parish of St. James, Westminster, in 1854.') Numerous other examples are recorded of the connection of cholera with the drinking of impure water.

With regard to the locality of houses, Dr. Farr has shown, for London, that nothing has so constant a relation to the fatality of cholera as the elevation of site. He has shown that, just as we ascend from the banks of the river Thames to the higher localities around it, the mortality of cholera diminished. This is undoubtedly connected with the fact that the greatest accumulation of organic refuse occurs on the banks of rivers into which the sewage of a city is poured.

The effluvia which pass off from decomposing animal and vegetable matter seem to have a great influence in predisposing the system to the reception of the choleraic poison. It is well known that the atmosphere of dissecting rooms, and places where animal bodies are decomposing, produce on those exposed to it a tendency to diarrhœa. This is also the case with the excretions of animals, when they are allowed to undergo putrefactive changes. Hence it has been found that diarrhœa and cholera prevail especially in those houses and streets which are undrained, and where human refuse is allowed to accumulate in cesspools. The instances recorded of the breaking out of cholera in the neighbourhood of foul drains, or of recently opened cesspools, are very numerous and conclusive on this point. In many towns in England, where the inhabitants suffered severely from a first attack, they obtained during the subsequent visitations an entire immunity, by the improvement of the drainage and the substitution of water-closets for privies and cesspools.

Independently of external causes, there are certain facts connected with the individual that act as predisposing causes. Thus, with regard to *age* and *sex*, Dr. Farr found that males suffered more than females at the ages under 25 years, but between 25 and 45 the females suffered more than the males. During the prevalence of cholera in Paris in 1832, it was found that the mortality was least from 6 years to 20, greater from 30 to 40, and greatest of all above 40 years. *Habits of life* exercise a great influence in predisposing to cholera, and there is no question that, in all countries, the lower classes have suffered more than the upper classes. This was observed in India, where, in all the large cities, the natives suffered more than the European population; where the Brahmin merchant suffered less than the ryot, and the ryot less than the pariah. In the cities of Europe, everywhere the poor and ill-fed suffered most. As a rule, Mohammedan nations have suffered more than European, and the Hindoos more than Mohammedans. As indicating the influence of low diet, it has been stated that the Mohammedans suffered much more during their rigid fasts. The excessive *use of alcoholic liquors* has everywhere been observed as a predisposing cause to cholera, whilst entire abstinence from them seems also to have invited attacks. Exhaustion from *fatigue* also invites the action of the poison. This has been remarkably exemplified in the movements of the army. When troops have been marched a long distance, they have been immediately seized with cholera on reaching their destination, whilst soldiers who have remained in camp during the same time have experienced no attack at all.

Treatment of Cholera.—Premising, in a prophylactic point of view, the superiority of avoiding all the predisposing causes of cholera to the absurd practice of swallowing specifics against the disease, our treatment must be regulated according to the state in which we find the patient. The diarrhœa may be treated by a dose of calomel and opium combined with some aromatic, at once, and small doses of opium should be continued every hour till the diarrhœa is restrained. Bleeding has been recommended at this period of the disorder, but all experience shows this to be a dangerous practice. If the patient is already in a state of collapse, the various modes of treatment which have been adopted prove how little is to be effected when the disease has advanced to this stage. Major Tulloch informs us that the principal remedy of the American aborigines consisted in merely swallowing large quantities of charcoal mixed with lard; yet very nearly the same proportion recovered as among the white inhabitants of the towns who had the advantage of the best medical science. In this country, blood-letting, cold affusion, hot-baths, emetics, purges, astringents, sedatives, and stimulants of the most powerful kind, have been successively tried with very doubtful advantage. The plan however which has excited most attention is that by salines. Medical men, guided by chemical analysis, conceived the project of supplying by artificial means the serum which was found wanting in the blood. With this view lavements and potions of an alkaline solution, resembling serum in composition, were administered; but not being able by this means to arrest the vomiting, it was recommended and put into practice by Dr. Latta of Leith to inject the same fluid into the veins. This was first done by means of one of Reid's syringes, the temperature of the solution being kept at from 108° to 110° Fahr. Of 74 bad cases treated in this method, 22 recovered, and in one case only did any unfavourable symptoms occur, and this was from phlebitis, or inflammation of the veins. As much as 33 lbs. of this alkaline solution have been injected in the space of 52 hours, and with a successful result. Some practitioners have even exceeded in amount this quantity. The composition of the saline injection employed by Dr. Latta consisted of two drachms of common salt and two scruples of carbonate of soda dissolved in sixty ounces of water; but this formula has been slightly varied in different cases. The immediate effects observed on injecting this fluid into the veins are, an increase of the temperature and respiration, a reappearance of the pulse, if before imperceptible, or it becomes fuller, stronger, and slower, when it was before small, frequent, and feeble. The collapsed appearance of the countenance gradually vanishes; it becomes fuller and more natural; the eyes brighten, the thirst diminishes, and the patient expresses himself in terms of gratitude or satisfaction at the wonderful change wrought in his feelings. But this change is evanescent; the purging continues, and the patient is shortly reduced to the same hopeless state in which he was previous to the adoption of this treatment.

The failure of all heroic methods of treatment has induced the trial of almost all possible forms of treatment. All the metals have been given, as well as the non-metallic agents, the vegetable alkaloids, and mineral acids. Emetics, purgatives, diuretics, sudorifics, all have been tried, and although many of these remedies have been vaunted as cures, the terrible logic of statistical calculation has demonstrated that no one system can claim to be more successful than another. At the commencement of the epidemic all die alike, as the more predisposed are cut down, a larger number recover, and it is at this period the medical practitioner begins to attribute the recoveries to the success of his treatment. The London College of Physicians obtained the returns of the treatment of several thousand cases, and came to no conclusion as to any particular system. It may, however, be remarked that whatever remedy was given it was accompanied with some of the preparations of opium, and contrasting those plans of treatment which contained opium as an element, with those in which this remedy was omitted, it was found that the former were the more successful. Amidst then the vast experience of remedies in this deadly malady we have only this fact presented with certainty that opium alone in one form or another offers some chance of relief.

PETALISM. [OSTRACISM.]

PETARD. [ARTILLERY.]

PETE'CHIÆ are small spots of a dark red colour produced by the effusion of drops of blood in the skin just beneath the cuticle. At first sight they look very like flea-bites, but they do not disappear when they are pressed with the finger. They usually indicate an altered state of the blood, and are often symptoms of very serious diseases, as in typhus fever (some varieties of which have hence been called petechial fever), scurvy, purpura, &c. They commonly appear also in very severe cases of small-pox, measles, and scarlet fever, and are amongst the worst symptoms by which those diseases are marked.

PETECHIAL FEVER. [PETECHIÆ.]

PETER-PENCE, a tax anciently levied throughout England, according to some authorities, of a penny upon each house; according to others of a penny upon every house which contained twenty pennyworth of any kind of goods, and paid to the pope. This payment, in ancient times, passed under various denominations: Rome-fee, Rome-penning, and Rome-scot were the Saxon names; Denarii S. Petri and Census S. Petri, in Latin. The earliest payment of it is attributed by some to Ina, king of the West Saxons, A.D. 720; by others to Offa, king of Mercia, A.D. 790. At one period of his reign, Edward III. discontinued this payment, but it was revived by Richard II. It finally ceased at the Reformation.

(Du Cange's *Glossary*; *Leg. Edw. Conf. & Will. Conq.*)

PETER'S, ST. [ROME, in GEOG. DIV.]

PETININE. Synonymous with *butylamine.* [ORGANIC BASES.]

PETIT-SERJEANTY. [SERJEANT.]

PETITION. A petition is an application in writing, addressed to the lord chancellor, in which the petitioner states certain facts as the ground on which he prays for the order and direction of the court. Petitions are either *cause* petitions or not. A cause petition is a petition in a matter of which the court has already possession by virtue of there being a suit concerning the matter of the petition; and the petitioner is generally either a party to such suit, or he derives a title to some interest in the subject-matter of the suit from a party to it. When there is no suit existing about the matter of the petition, it is called an *ex parte* petition.

Some cause petitions are called petitions of course, and relate to matters in the ordinary prosecution of a suit, and before a decree. Such petitions are granted upon application of the party petitioning; and they may be presented at any time, whether the courts are sitting or not.

Other petitions in a cause, which are not petitions of course, and may be called special petitions, have for their object to carry a decree into execution. Thus a party who has an interest in a fund in court, a legatee for instance who was a minor when the decree was made, may, when he is of age, apply by petition to have his share paid to him, because his right to it has been recognised by a decree or order of the court, or by a master's report which has been confirmed. The nature of the petitions in a cause will of course vary with the subject-matter of the suit.

Petitions, not in a cause, are of various kinds, and many of them are presented under the authority of particular acts of parliament. These also are called special petitions. Thus a petition may be presented for the appointment of guardians to infants, and for an allowance for their maintenance; for the purpose of procuring an order of court that infant trustees and mortgagees may execute conveyances; and for various other purposes. In matters of lunacy, the form of proceeding in the first instance is by petition, the prayer being for a commission to inquire into the state of mind of the alleged lunatic. [LUNACY.] In subsequent proceedings relating to the property of a person, when found lunatic by a jury, a petition is the regular and usual course of proceeding; and suits are not commenced or defended for the lunatic without the previous approval and direction of the court.

All special petitions must be presented to the court to which they are addressed, in order to be answered: until they are answered, the court is not fully possessed of the matter of the petition. The answer, which is written on the copy of the petition and signed by the judge, requires the attendance before him of all parties concerned in the matter of the petition at the hearing thereof. It is the business of the petitioning party to serve all proper parties with notice of this petition, and the answer to the petition becomes an order of the court, upon every person whom the petitioner chooses to serve with the petition, to attend at the hearing of it; and if such person be absent at the hearing, he will be bound by the order made on the petition. Service of the petition consists in delivering a true copy of the petition as answered to the clerk in court whose attendance the petitioner thinks necessary, or to the party himself. In some special cases, the petitioner is permitted, on special motion, supported by an affidavit that he is unable to serve the party personally, to leave the copy of the petition at the party's house with one of his family, and this will be considered good service. Special petitions frequently require to be supported by affidavits of the petitioner or some other person, or of both; and such affidavits may be filed at any time after the petition is answered. If a petitioner choose to serve a party with a petition, whose presence is considered by the court to be unnecessary, he must pay such party the cost of attending at the hearing of the petition.

A petition is heard in court by the counsel for the petitioner stating the substance and prayer of the petition, and by reading or briefly stating the contents of the affidavits filed in support of the petition, if any have been filed. If the prayer of the petition is opposed by any of the parties who have been served with it, they are heard by their counsel, and their affidavits also, if any have been filed, are read or briefly stated to the court. On hearing the matter of the petition and the affidavits on both sides, the court either dismisses the petition or makes such order as it thinks fit. The order when made is drawn up, passed, entered, served, and enforced like any other decree or order of the court.

PETITION OF RIGHT. Where the crown or a subject has a cause of action against a subject, the ordinary mode of putting that cause of action into a course of legal investigation is by the king's writ, requiring the party to appear in court to answer the complaint. Where the claim is against the crown itself, as this course cannot be pursued, the mode of proceeding provided by common law is to present a petition to the crown, praying for an inquiry and for the remedy to which the party conceives himself to be entitled. As by Magna Charta the king is not to delay right, he is bound, if the petition presents that which has the semblance of a legal or equitable claim, to indorse the petition with the words "let right be done;" which indorsement operates, in the case of a claim of a legal nature, as a warrant and command to the lord chancellor to issue a commission to inquire into the truth of the matters alleged in the petition. A commission accordingly issues to six or eight persons, who summon a jury, of whom not less than twelve or more than twenty-three are impannelled, and who, under the superintendence of the commissioners, hear the evidence which the petitioner, or, as he is called, the suppliant, has to adduce in support of his statement. If the jury negative the allegations contained in the petition, the commission is at an end; but the suppliant is at liberty to sue out a new commission or commissions till a jury return an inquisition in which the allegations are found to be true. The crown may, upon this return, insist that the facts alleged by the suppliant, and found by the inquisition, do not in point of law entitle the suppliant to the remedy which he claims. The question of law thus raised by demurrer to the inquisition is argued before the lord chancellor. The crown, however, notwithstanding the finding of the jury, may deny the truth of the facts, or, admitting them to be true, may allege other facts which show that the suppliant is not entitled to what he claims. To such facts the suppliant must reply. Any issue of fact joined between the suppliant and the crown is tried in the court of Queen's Bench, the lord chancellor not having the power to summon a jury. Final judgment is given for or against the suppliant according to the result of the argument upon the demurrer or of the trial of the issue.

If the suppliant in his petition pray that the investigation may take place in a particular court, and the royal indorsement on the petition directs that course to be pursued, the proceedings take place in the court indicated by the indorsement, instead of the Court of Chancery.

Before the abolition of the feudal tenures by the Commonwealth (confirmed after the Restoration, by 12 Car. II., c. 24), the rights of the crown and of the subject being often brought into collision, occasions for proceeding by petition of right were very frequent, and as this mode of proceeding was dilatory and expensive, two acts, passed in the reign of Edward III., enabled parties aggrieved in certain cases by legal proceedings of the crown, to enter their claim upon those proceedings, without being put to their petition of right, with its expensive commission to inquire. This new course was called a "traverse of office," where the subject denies the matters contained in the "office" or *ex parte* record constituting the king's title, and a "monstraunce de droit," where the facts upon which the king's title rests are admitted, but their effect is avoided by the allegation of other facts showing a better title in the claimant. In modern practice the petition of right is not resorted to, except in cases to which neither a traverse of office nor a monstraunce de droit applies, or after those remedies have failed.

The petition of right is supposed by Lord Coke and others to be so called because the investigation prayed for is demandable as of right, and not granted as a matter of grace or favour; but the Latin term "petitio justitiæ," shows that the words are used in the sense of a "petition *for right*."

The petition of right hitherto spoken of is the method of redress provided by the common law. The statute 23 & 24 Vict. c. 35, has provided a simpler mode of proceeding. It enables the suppliant to entitle his petition in any of the supreme courts of law or equity, at Westminster; and to leave the same with the home secretary for the fiat of the crown. When this fiat is obtained, the petition is served on the solicitor to the treasury, who must appear and answer it, in the name of the attorney-general; all the subsequent pleadings and proceedings, including the trial, being according to the ordinary practice of the court in which the suit is pending. The suppliant and the crown in proceedings under this statute may recover costs, which are neither paid nor received by the crown upon a petition of right at common law, so that the statutory proceeding must in due course supersede the other.

(*Blackst. Com.*,' Mr. Kerr's ed., vol. iii., ch. 17.)

PETITION OF RIGHT. In the first parliament of Charles I., which met in 1626, the commons refused to grant supplies until certain rights and privileges of the subject, which they alleged had been violated, should have been solemnly recognised by a legislative enactment. With this view they framed a petition to the king, in which, after reciting various statutes by which their rights and privileges were recognised, they pray the king "that no man be compelled to make or yield any gift, loan, benevolence, tax, or such-like charge, without common consent by act of paliament,—that none be called upon to make answer for refusal so to do,—that freemen be imprisoned or detained only by the law of the land, or by due process of law, and not by the king's special command, without any charge,—that persons be not compelled to receive soldiers and mariners into their houses against the laws and customs of the realm,—that commissions for proceeding by martial law be revoked: all which they pray as their rights and liberties according to the laws and statutes of the realm."

To this petition the king at first sent an evasive answer:—"The king willeth that right be done according to the laws and customs of the realm, and that the statutes be put in due execution, that his subjects may have no cause to complain of any wrongs or oppressions contrary to their just rights and liberties, to the preservation whereof he holds himself in conscience obliged as of his own prerogative." This answer being rejected as unsatisfactory, the king at last pronounced the formal words of unqualified assent, "Let right be done as it is desired." (1 Car. I., c. 1.) Notwithstanding this, however, the ministers of the crown caused the petition to be printed and circulated with the first insufficient answer.

PETROLIN. [BITUMEN.]

PETROSELINUM. [PARSLEY.]

PEUCEDANIN. [IMPERATORIN.]

PEUCYL. *Terebilene.* A liquid resembling camphine, obtained by the action of lime upon the monohydrochlorate of turpentine.

PEUTINGERIAN TABLE is the name given to a map of the roads of the ancient Roman world, which is on parchment, and was found in a library at Speyer in the 15th century. It was bequeathed by the proprietor Conrad Celtes to his friend Conrad Peutinger, a learned man of Augsburg, who began to prepare a copy of it for publication, but died in 1547, before he could effect his purpose. Mark Velter however copied it on a scale less than one-half of its original size, and sent his copy to Ortelius, who forwarded it to Muretus, who published it in 1598. This reduced copy has been inserted in the Ptolemy of Bertius, in Horn's 'Orbis Delineatio,' and in Bergier's 'Histoire des grands Chemins de l'Empire Romain.' The original map remained at Augsburg, in the possession of Peutinger's descendants, till 1714, when it was purchased by a bookseller, and sold by him to Prince Eugene, who gave it to the imperial library of Vienna. An exact copy of it was made by F. C. Von Scheyb, at Vienna, with an introduction and index, and dedicated to the empress Maria Theresa; 'Tabula Itineraria Peutingeriana, quæ in Augusta Bibliotheca Vindobonensi nunc servatur, adcurate exscripta à Fr. Christoph. De Scheyb, cum Indice,' fol., Vienna. 1753. The map is 21 feet in length, and about one foot wide. The author, whoever he was, did not intend to draw a proper geographical map, with the relative positions of countries, but merely to collect all the great roads of the empire into a long narrow strip, marking the stations upon each, and the distances between the stations, for the information of travellers and chiefly of military and civil officers. The towns on the roads are marked by small houses; some, being worthy of particular notice, are designated by square buildings like barracks; and some more important towns and military stations, such as Aquileia, Ravenna, &c., are distinguished by walls and towers. Rome is distinguished by a circle with a crowned figure seated in the middle, and the port of Trajan is conspicuously sketched near the right bank of the Tiber, at the mouth of the river. Constantinople is marked by a circle and a figure, which however is not crowned. Antioch is the only other city which is also distinguished by a circle and a figure, in which last Mannert thinks that he recognises the Virgin Mary, which he believes to be an interpolation of some copyist of the middle ages, who had before him an older map of the time of the Pagan emperors. (Mannert's 'Introduction' to his new edition of Peutinger's Table, folio, Leipzig, 1824.) That the original map was drawn while the old religion of the empire was still dominant, seems proved by the heathen temples which are marked upon it, whilst there is no Christian name, with the exception of St. Peter's at Rome, which is probably also an interpolation of the copyist.

Several other particulars on the map seem to fix the date of its original construction to about the time of Alexander Severus, after the Persians had overthrown the Parthian dominion, A.D. 226. The Persian empire is marked in its full extent and written in large capitals, whilst Parthia is indicated by smaller characters as a province. Palmyra is marked as an important place, with roads leading to it through the desert, which would seem to refer to an epoch previous to its destruction by Aurelian. Edessa in Macedonia is marked under that name, whilst in the Antonine Itinerary it is called Diocletianopolis. This and other evidence collected by Mannert indicate at all events an epoch between the reign of Alexander Severus and the end of the 3rd century, making allowance for the interpolations of subsequent copyists.

The Peutingerian Table does not always agree with the Antonine Itinerary; several stations and towns which are in the one are not in the other; the distances between the stations marked on both sometimes disagree; besides which, in consequence of the form of the map, several roads which are distinct on the Itinerary are placed on the map consecutively, as if they all formed one line; whilst others, which are single roads on the Itinerary, are cut into two or three in the map. However the Itinerary is still of great use in explaining the map, and the two together are among the most valuable ancient works on geography which have come down to us.

The map extends to the right, or east, as far as the mouths of the Ganges. Roads are traced through India to several emporia, or places of trade, on the coast. To the west the map ends abruptly on the borders of Spain, including farther north only the eastern part of Britain. It is evident, as Mannert maintains, that one leaf is wanting, and it has perhaps been lost.

PEW. The word pew seldom occurs in writers upon ecclesiastical law, who almost invariably use the expression "church seat."

Originally there were no pews in churches, and the only fixed seats were stone benches carried along the sides of the churches, of which examples still remain in Salisbury and other cathedrals, and in Romsey church, Hants, Portbury, Somersetshire, and many other of our old parish churches. But in the 14th, and still more generally in the 15th century, open seats or benches of wood, with carved ends, were fixed across the nave (but leaving a broad central passage), though the practice was still perhaps not universal. These, legally termed "church seats," were commonly called "pews," but pews in the modern sense of the word, namely, enclosed seats, did not come into use until about the period of the Reformation. Before that time no cases are to be found of claims to pews, although in the common-law books two or three claims are mentioned to seats in a church, or particular parts of a seat.

By the general law and of common right, all the pews in a parish church are the common property of the parish; they are for the use *in common* of the parishioners, who are all entitled to be seated orderly and conveniently so as best to provide for the accommodation of all. The right of appointing what persons shall sit in each seat belongs to the ordinary and the churchwardens, who are his officers to place the parishioners according to their rank and station. A parishioner has a right to a seat in the church without any payment for it; and if he has cause of complaint in this respect against the churchwardens, he may cite them in the ecclesiastical court to show cause why they have not seated him properly; and if there be persons occupying pews who are not inhabitants of the parish, they ought to be displaced in order to make room for him. This general right, however, of the churchwardens as the officers of the ordinary is subject to certain exceptions, for private rights to pews may be sustained upon the ground of a faculty, or of prescription, which presumes a faculty.

The right by faculty arises where the ordinary or his predecessor has granted a licence or faculty appropriating certain pews to individuals. Faculties have varied in their form: sometimes the appropriation has been to a person and his family "so long as they continue inhabitants of a certain house in the parish;" the more modern form is to a man and his family "so long as they continue inhabitants of the parish" generally. The first of these is perhaps the least exceptionable form.

Where a faculty exists, the ordinary cannot again interfere; but where a party claiming by faculty ceases to be a parishioner, his right is determined. There may be, however, a prescription for a person living out of the parish to have a pew in the *body* of the church.

With respect to seats in the chancel, the law has not been settled, and great inconvenience has been experienced from the doubts continued to be entertained. It is said that the churchwardens have no authority over pews in the chancel, and it has been said that the rector, whether spiritual or lay, has in the first instance at least a right to dispose of the seats; claims have also been set up on behalf of the vicar; and the extent of the ordinary's authority to remedy any undue arrangement with regard to such pews has been questioned.

With regard to aisles or isles (wings) in a church, the case is different. The whole isle, or particular seats in it, may be claimed as appurtenant to an ancient mansion or dwelling-house, for the use of the occupiers of which the aisle is presumed to have been originally built. In order to complete this exclusive right, it is necessary that it should have existed immemorially, and that the owners of the mansion in respect of which it is claimed should from time to time have borne the expense of repairing that which they claim as having been set up by their predecessors.

The purchasing or renting of pews in churches is contrary to ecclesiastical law, pew-rents, under the church-building acts, being exceptions to the general law; and rents taken in populous places being usually sanctioned by special acts of parliament. Pew-rents in private unconsecrated chapels do not fall under the same principle, such chapels being private property.

PEWTER. An alloy of tin and lead, intermediate in hardness between lead and Britannia metal. The best pewter consists of four parts of tin and one of lead.

PHALANX (φάλαγξ), a name given by the Greeks generally to the whole of the heavy-armed infantry in an army, but particularly to each of the grand divisions of that class of troops. The primary signification of phalanx is uncertain; a straight bar or rod of any material appears to have been so called, and the word may have been applied to a corps of troops, in line, from a fancied resemblance in the latter to such object. Ultimately, from their superior military efficiency, it became appropriated to the Spartan phalanx and the Macedonian phalanx.

The Greek troops are represented by Homer as disposed in masses consisting of many ranks, in order that they might resist, or give impetus to the shock of conflict; and the word *phalanges* is, in several parts of the Iliad, applied to the masses of the combatants, both Greeks and Trojans:

'Αμφὶ δ' ἄρ Αἴαντας δοιοὺς ἵσταντο φάλλαγγες

('Il.,' xiii. 126; see also 'Il.,' iv. 332, vi. 83); and the close order of the Greeks previously to coming into action is described in 'Il.,' xiii. 130, and the succeeding lines.

A like disposition prevailed among the Egyptians in the earliest times of their monarchy, and of this fact some interesting vestiges are preserved in the sculptures on the walls of the temples at Ipsambul and of the palace at Luxor. At the former place an Egyptian army is represented as marching in separate divisions of chariots and foot soldiers drawn up in quadrangular bodies, in ranks, and in close order. Each man of the infantry is armed with cuirass and helmet, and carries a shield and a short javelin; and among the figures is that of Sesostris in full panoply, standing in a highly ornamented car. (Rosselini, 'I Monomenti dell' Egitto,' plates 87 to 103.) But, from the nature of the arms and the apparent discipline of the troops, it may be inferred that, at the epoch to which the monuments relate, the tactics of the Egyptians were in a very advanced state, and consequently that the order of battle there represented was in use among that people at a time much more remote than the age of Sesostris.

The ancient Jewish army, modelled probably on that of the people who had long held them in servitude, was divided into bodies of 1000 men each, which were again divided into companies of 100 men (2 Sam., c. 18); and it is plain, from other passages in the Scriptures, that these were further subdivided into sections. It consisted both of heavy and of light armed troops: the former wore helmets, coats of mail, and greaves, and in action they carried bucklers and used both spear and swords; the latter also carried shields and used bows or slings. The men who, from the different tribes, assembled at Hebron to confirm the election of David, are described as being armed with spear and shield, and their discipline is indicated by the expression—they could keep rank.

The troops in the army of Crœsus are said by Xenophon to have been drawn up in vast masses, the depth of the Lydians being thirty men, while that of the Egyptian auxiliaries was one hundred; and it is added that the whole army had the appearance of three great *phalanges*. ('Cyropædia,' lib. vii.) It is sufficiently evident therefore that the deep order of battle, with a regular arrangement of the men in rank and file, and some systematical division of the phalanx into sections, prevailed in the earliest times; but it is to the Greek writers that we must go for an account of the particular scales of subdivisions by which the evolutions of the phalanx on the field of battle were facilitated, and which, joined to the high discipline of the troops, gave to the body so denominated the reputation which it enjoyed till the fall of the Macedonian kingdom. The formation of such scales of subdivisions, and some changes in the arms or armour of the men, are probably what are meant when it is said that Lycurgus, Lysander, and Epaminondas introduced the *phalanx* among the Lacedæmonians, the Argives, and the Thebans. The Macedonian phalanx, the formation of which is ascribed to Philip, the father of Alexander, appears to have been a body of 6000 men, chosen for their good military qualities, particularly well armed, and subject to certain strict regulations. And its efficiency was so great, that it is styled a new invention by Diodorus, and the name of the country became afterwards very generally applied to it.

Xenophon, though constantly using the word *phalanx* in speaking of the whole body of troops which he commanded in the retreat from Cunaxa, when he has occasion to mention the formation or employment of a small body of men for any particular purpose, gives it the name of λόχος, and such body appears to have consisted either of 50 or 100 men. On one occasion, some lochi being detached from the army, two of them, amounting to 100 men, are said to have been cut off ('Anabasis,' lib. i.); and at another time, from an apprehension that the order of the phalanx would be broken in ascending a mountain, the army was divided into separate lochi of 100 men each. ('Ib.,' lib. iv.) But in the 'Cyropædia' (lib. ii.) a division of 100 men is called τάξις, and this is stated to have been subdivided into sections of ten and of five men each. The scale just hinted at was probably peculiar to the Athenian army, for Xenophon describes the Spartan troops as formed into six μόραι, each commanded by a polemarch; he adds also that the mora was divided into four λόχοι, eight πεντηκοστὺς, and sixteen ἐνωμοτίαι, in which the number of men appears to have varied, and to have consisted of from 25 to 36 men. ('De Repub.,' lib. xi.) The mora is said to have consisted of 600 men, but its strength appears to have varied considerably at different times. These were the divisions of the Spartan phalanx.

The only existing works expressly written on the subject of the Greek tactics are those of Ælian and his abbreviator Arrian, and these authors lived in the time of Hadrian and Antoninus, that is, long after the age in which the phalanx was superseded by the legion. Therefore, since their descriptions do not agree with what we find concerning the phalanx in the works of Thucydides and Xenophon, it seems reasonable to conclude that they appertain to the state of this body of troops in and subsequent to the times of Philip and Alexander. Ælian makes the Macedonian phalanx to consist of 16,384 men of the class called ὁπλῖται, or heavy-armed infantry; but this must be understood to be the whole body of that denomination in an army, and to be composed of four simple phalanges. Joined to the phalanx is a division (ἐπίταγμα), consisting of half that number of men of the class called ψιλοὶ, or light-armed troops, and another, called also an epitagma, of cavalry (ἱππεῖς). consisting of one-fourth of the number.

The *peltastæ* (πελτασταί), who are also mentioned by Ælian, but not as appertaining to the phalanx, united in some measure the firmness of the heavy with the agility of the light armed men. They were first instituted by the Athenian commander Iphicrates, and in the course of time they became very numerous in the Greek armies: they served as the guards of the princes, and were often reckoned among the heavy-armed troops.

The simple phalanx, according to Ælian, consisted of 4096 men; one half of that number, or 2048 men, constituted the merarchy (μεραρχία); and one-fourth, or 1024 men, was called a chiliarchy (χιλιαρχία). One-fourth of the last constituted a syntagma (σύνταγμα), or xenagy (ξεναγία), which was a complete square of 16 men each way; and the lowest subdivision was called lochus (λόχος), decuria (δεκὰς), or enomoty (ἐνωμοτία), which is, by that writer, considered as a single file of 16 men. The officers do not appear to be included in the numbers of the different divisions: each xenagy had its own chief or captain (συνταγματάρχης) at the head, and a lieutenant (οὐραγός) brought up the rear. The leader of a single file is called, by Ælian a decurion, perhaps because originally the file consisted of 10 men. A phalangarch commanded each phalanx.

Ælian divides the epitagma of light troops into sections, each of which has half the strength of the corresponding division in the phalanx; the lowest division is the lochus or file, which consists of 8 men. The epitagma of cavalry is divided in the same proportions as the bodies of infantry, down to the lowest subdivision, which is called ἴλη, and is made to consist of 64 men.

The phalangists were armed with helmet, cuirasses, and greaves; and in the early ages they carried an oval buckler and a pike, the latter about 10 feet long. The change introduced by Philip in the arms of the hoplitæ consisted in the substitution of a larger shield, and of the *σάρισσα*, a pike from 18 to 20 feet long. The arms of the peltastæ seem to have differed from those of the hoplitæ chiefly in the buckler (from whence their designation is derived) being round and only about two feet three inches in diameter, and in the pike being short. It is said that Iphicrates, instead of a metal cuirass, allowed to this class of troops only a corslet of strong linen; but apparently this regulation was not always followed. The light-armed troops were frequently provided with a helmet only, and their arms were small javelins, bows, or slings.

A phalanx, in line, was considered as being constituted of two equal parts or wings (κέρατα); there was no central division, but the place of junction of the two wings was called the ὀμφαλὸς. In the usual order of battle it was drawn up with its front parallel to that of the enemy, but it not unfrequently happened that one wing was kept retired. This last method was practised by Epaminondas at the battle of Leuctra; the wing engaged was strengthened so as to have 50 men in depth, and the line gradually diminished to the opposite extremity, where it was only six men deep. Sometimes also two phalanges advanced in columns, with their heads united, the two lines gradually diverging to the right and left; and this is that disposition which was called ἔμβολον, or the wedge.

The phalanx was frequently drawn up in the form of a quadrangle, which might be solid or hollow, according to circumstances; and this disposition was called the plinth (πλινθίον), or the plæsium (πλαίσιον). When a double phalanx was formed with their fronts in reversed positions, the order was called ἀμφίστομος. The order called ἀντίστομος seems to have been similar to the last, except that the men faced in opposite directions, from the centre towards the wings.

When standing at open order, each soldier in the phalanx was allowed a square space about six feet each way; but when prepared for action, this was reduced to three feet, and occasionally to about eighteen inches. The file-leaders and the rear-rank men were always chosen from the best of the troops, for on the first depended chiefly the success of the charge, and the latter performed the important duty of urging on the men immediately before him, in order that the whole body might not give way by the counter-pressure of the enemy's mass.

After the introduction of the Macedonian sarissa, above mentioned, the phalanx might present a formidable array of five ranks of such weapons projecting horizontally before the front of the line; for, admitting the men to be three feet from each other in depth, and that each man held in his hands about six feet of the length of the weapon, the point of that which belonged to the fifth man would project two feet beyond the file leader. Ælian also mentions another and perhaps a preferable practice, which was that of giving to the men from the first to the third or fourth rank spears successively longer in proportion to the distance of the rank from the front; in which case all those weapons must have projected equally before the line of troops.

The position of the phalanx was sometimes changed by a wheel of the whole body on either extremity as a pivot; and this was done with the men drawn up in close order. But the reversion of the front was performed in one of the three following ways:—The Cretan method, as it was called, consisted in making each file countermarch almost upon the ground it occupied, the file-leader going to the right-about, and moving to the rear, all the men of the file following him till the rear-rank man came into the line which was before the front. The Spartan method was also performed by a countermarch, but the file-leader moved to the rear, followed by the other men, till he arrived at a distance from his first place equal to twice the depth of the phalanx, the rear-rank man only changing his front. Lastly, the Macedonian method was performed by the front-rank man going right about on his own spot, the others passing him in succession and arranging themselves behind him. These movements appear to have been preferred by the Greeks to a simple change of front to be effected by making each man turn upon the ground he occupied, since they allowed the file-leaders to constitute always the foremost rank of the line.

The number of men in front of the phalanx was doubled by causing every second man in the depth to move up to the interval between every two men in the rank immediately before him; thus reducing the depth of the phalanx to eight files without extending the front. And when the front was to be extended without increasing the number of men in it, the troops merely, by a flank movement, opened out from the centre each way. Arrian justly observes that these evolutions should be avoided when in presence of the enemy; and he adds that it would be preferable to extend the front by bringing up cavalry or light troops to the wings.

On a march, the phalanx was thrown into a column, whose breadth depended on that of the road; and a formation of some separate bodies, consisting of 100 men each, for the purpose of protecting the main body while returning to its former order after having passed a defile, is mentioned by Xenophon ('Anabasis,' lib. iii.) as being then, for the first time, employed. The march of two phalanges in parallel and contiguous columns is stated to have been sometimes made by the columns keeping their proper fronts towards the exterior; but sometimes both columns were in like positions, the front of one and the rear of the other being towards the exterior, on the two sides of the line of march.

The strength of a Grecian army consisted in the deep array of its heavy infantry. No body of men less protected by defensive armour could make any impression upon the solid phalanx: and the latter, by the momentum of its charge, could not fail to overwhelm any troops who were differently formed. But the advantage of the phalanx, while it continued embodied, did not extend beyond the immediate field of battle; and the enemy, if he thought proper to decline an engagement, could, without interruption, except that which might arise from the light-armed troops and cavalry, ravage the country, and by cutting off its supplies compel the army to retreat. The phalanx moreover could only be advantageously employed on ground which was nearly level and free from obstacles; since whatever tended to derange its compact order, necessarily diminished or annulled the effect of its charge. At the battle of Issus, the phalanx of Alexander, while in a state of disorder, as the troops were passing the river, was engaged with the Greeks in the service of Darius; and though it succeeded in repelling the enemy, it sustained considerable loss. (Arrian, 'Exped. Alex.,' lib. ii.)

Polybius, in comparing (lib. xvii., extract 3) the efficiency of the phalanx with that of the Roman legion, observes that the latter never opposed the former on a line parallel to its front, but always with one wing thrown back; by which means it broke the line, or else compelled the phalanx to change its disposition; in either case there were formed intervals of which the legionary soldiers could avail themselves to engage the phalangists in flank, and thus render their close array and their unwieldy weapons useless.

PHANTASCOPE. An amusing toy based on the principle of the persistence of impressions on the retina, after the object has changed its position. The *Thaumatrope* and *Phenakistascope* rest on the same principle.

PHANTASMAGORIA. [Magic Lantern.]

PHARISEES, a sect among the ancient Jews. The name is derived from the Greek Φαρισαῖοι, and this most probably from the Hebrew פָּרַשׁ, *parash*, to separate. Suidas says, "The Pharisees are by interpretation ἀφωρισμένοι (the separated), because they divided and separated themselves from all others, in exactness of life and in attention to the injunctions of the law."

The origin of this sect is unknown. Josephus, who was himself one of the Pharisees, speaks of them as flourishing long before he was born. He says ('Antiq.,' b. 13, c. 9), "At this time (about 150 B.C.) there were three sects of the Jews, the Pharisees, the Sadducees, and the Essenes." On several occasions he describes the Pharisees as the chief sect, and as possessing great authority among the people.

They believed in the existence of angels and spirits, and held the doctrine of the resurrection; but their notion of the latter appears to have been Pythagorean, namely, that there is a resurrection of the soul only by a transmigration into another body. From the benefits of this resurrection they shut out all the notoriously wicked, consigning them at once to eternal misery, upon the separation of the soul from the body. While the Essenes maintained that all things were ruled by absolute fate, and the Sadducees that all things were under human control, the Pharisees adopted a middle course, maintaining that some things were predestinated, and others left for men to determine. It was a leading maxim of the Stoics that some things were in our power, and others not in our power; and Josephus tells us that the sect of the Pharisees was very much like that of the Stoics.

But they were mainly distinguished by their zeal for "the traditions of the elders," to which they attached an importance equal to that of the Mosaic writings; and it was from a strict adherence to these traditions, as well as from an observance of the punctilios of the law itself, that they were called Pharisees. Several of these traditions are mentioned in the New Testament, but they are only a small portion of the whole. "To go through them all," says Prideaux, "would be to transcribe the Talmud, a book of twelve volumes in folio."

The Pharisees are represented in the New Testament as a hypocritical, proud, and arrogant people, pretending to be emphatically "the separated," trusting to themselves that they alone were righteous, and despising all other men. This was their character as a body; but there were among them individuals free from these bad qualities, such as Nicodemus, Joseph of Arimathæa, Gamaliel, and, as some think, Simeon, who uttered the hymn called "Nunc dimittis," to whom must be added Josephus, their historian.

(Josephus, *Antiq.*, xiii. 9, 18; xvii. 3; xviii. 2; *De Bell. Jud.*, ii. 7; *De Vitâ suâ*; Suidas, Φαρισαῖοι; Prideaux, *Connection*; Jahn, *Heb. Ant.*, b. iii., c. 1, §§ 316–20.)

PHARMACOPŒIA, a book published by the colleges of physicians with the sanction of government, containing directions for the preparation of medicines.

PHA'RMACY, in a comprehensive sense, means the department of natural science which treats of the collection, preparation, and preservation of medicines, and also of the art of dispensing them according to the formulæ or prescriptions of medical practitioners. It is however more commonly used in a limited sense, as a branch of chemical science, and termed pharmaceutical chemistry, or the application of the laws of chemistry to those substances which are employed for the cure of diseases, so as to render them more commodious, or their administration more easy, and their action more perfect and certain. It should not be understood as merely depending upon some mechanical processes, such as trituration, rasping, or other means of subdivision, or even the simpler chemical actions involved in the processes of infusion or decoction, but as requiring a knowledge of vegetable physiology, and an acquaintance with the chemical constitution of the substances to be prepared. In many continental nations this department is the subject of very strict legal enactments, and forms an important part of medical police, especially as regards the dispensing of poisonous drugs; while in Britain any one who chooses may affix the terms chemist and druggist to his name, and may deal in the most useful or dangerous ingredients, without that previous education which would fit him to be the appropriate assistant to the physician, whose most judicious plans are often frustrated by the ignorance or carelessness of those to whom the compounding of his prescriptions are entrusted. Efforts are making both in parliament and out, by the Sale of Poisons bill, and other measures, and still more by the precautionary exertions of the Pharmaceutical Society, founded by the late Jacob Bell, to remove this reproach. [MATERIA MEDICA.]

PHASE (φάσις, *phasis*, appearance). When a phenomenon changes its character gradually, any particular state which it is necessary to distinguish is called a phase. Thus we have the phases of the moon, meaning the different forms which the enlightened part takes during the month; the phases of the weather, meaning the succession of heat and cold, wet and dry, &c.

PHASES OF THE MOON. [MOON.]

PHENAMIDE. [ANILINE.]

PHENAMYLOL. [PHENYLIC GROUP.]

PHENATES. [PHENYLIC GROUP.]

PHENETOL. [PHENYLIC GROUP.]

PHENIC ACID. [PHENYLIC GROUP.]

PHENIC ALCOHOL. [PHENYLIC GROUP.]

PHENYL. A prefix used in organic chemistry to denote the presence of the radical phenyl in the compound to the name of which it is added. Descriptions of such bodies will generally be found under the name of the compound to which it is prefixed.

PHENYLAMINE. [PHENYLIC GROUP.]

PHENYL-BENZAMINE. [BENZOIC GROUP.]

PHENYL-BIBENZAMINE. [BENZOIC GROUP.]

PHENYL-CAMPHORAMIC ACID. [CAMPHOR.]

PHENYL-CAMPHORAMIDE. [CAMPHOR.]

PHENYL-CARBAMIC ACID ($C_{14}H_7NO_4$) *Carbinilic acid, Anthranilic acid.* The action of potash upon indigo or phenyl-urea produces phenyl-carbamic acid, which crystallises in colourless prisms, slightly soluble in cold water, but easily dissolved by hot water.

PHENYL, CYANIDE OF. [BENZOIC ACID.]

PHENYL-FORMIAMIDE. [FORMYL.]

PHENYLIC GROUP. This is one of the groups of organic compounds that belong to the BENZOIC SERIES. It includes a great number of substances, of which the chief are at present only scientifically interesting, at the same time many are employed in the arts; as for example, aniline, benzole, and carbolic and carbazotic acids.

Phenyl ($C_{12}H_5$) is the radical contained in, or from which are derived, all the members of the phenylic group. It and its derivatives somewhat resemble methyl and the compounds of methyl. While methyl, however, belongs to those radicals having the general formula $CnHn+1$, phenyl obviously belongs to those of the general formula $CnHn-7$. Phenyl itself has not yet been isolated.

Hydride of phenyl ($C_{12}H_5, H$), *phene* or *benzole* or *benzine*, has already been treated of in a separate article [BENZOLE]. Under the same head are also described the chlorine, bromine, and peroxide of nitrogen, derivatives of hydride of phenyl. The peroxide of nitrogen derivative, or *nitrobenzol* $\left(C_{12}\left\{\begin{matrix}H_4\\NO_4\end{matrix}\right\}, H\right)$ yields AZOXIBENZIDE on being heated with alcoholic solution of potash; and azoxibenzide yields AZOBENZIDE by distillation. By the action of reducing agents, such as sulphide of ammonium, azoxibenzide, and azobenzide yield *benzidine* ($C_{24}H_{12}N_2$). Benzidine occurs in lustrous white plates, soluble in boiling water, alcohol, or ether. With acids it forms crystalline salts from solutions of which caustic alkalies throw down a white precipitate of benzidine.

Hydrated oxide of phenyl ($C_{12}H_5O, HO$). *Phenic acid. Phenic alcohol. Phenol. Carbolic acid.* This body is produced in the manufacture of coal gas; hence, the name *phenic*, and thence *phenyl*, from the Greek *φαινω*, "I light," in allusion to the use of coal gas. The method of isolating, and the properties of phenic alcohol have already been detailed [CARBOLIC ACID.] It combines with bases to form *phenates*, some of which are crystalline.

By the ordinary processes of substitution, phenic acid gives rise to the bodies whose names and formulæ are here appended. Many of them were discovered by Laurent, who gave them peculiar, but convenient, names on a principle already alluded to under NAPHTHALIC GROUP.

Phenic or carbolic acid	$HO, C_{12}(H_5), O$
Bichlorophenic acid or chlorophenesic acid . .	$HO, C_{12}(H_3Cl_2), O$
Trichlorophenic acid, or chlorophenisic acid, or chlorindoptic acid	$HO, C_{12}(H_2Cl_3), O$
Pentachlorophenic acid or chlorophenusic acid . .	$HO, C_{12}(Cl_5), O$
Bromophenic acid or bromophenasic acid . .	$HO, C_{12}(H_4Br), O$
Bibromophenic acid or bromophenesic acid . .	$HO, C_{12}(H_3Br_2), O$
Tribromophenic acid, or bromophenisic acid, or bromindoptic acid	$HO, C_{12}(H_2Br_3), O$
Nitrophenic acid or nitrophenasic acid . . .	$HO, C_{12}(H_4NO_4), O$
Bichloronitrophenic acid or chloronitraphenisic acid	$HO, C_{12}(H_2Cl_2NO_4), O$
Bi-iodonitrophenic acid or iodenitraphenisic acid .	$HO, C_{12}(H_2I_2NO_4), O$
Binitrophenic acid or nitrophenesic acid . .	$HO, C_{12}(H_3 2NO_4), O$
Bromobinitrophenic acid or bromanitrephenisic acid	$HO, C_{12}(H_2Br 2NO_4), O$
Trinitrophenic acid, picric acid, or nitrophenisic acid, or CARBAZOTIC ACID	$HO, C_{12}(H_2 3NO_4), O$
Picranisic acid (isomeric with trinitrophenic acid) .	$HO, C_{12}(H_2 3NO_4), O$

Binitrophenic acid and trinitrophenic acid respectively yield *nitrophenamic acid* ($C_{24}H_{12}(NO_4)_2N_2O_4+4Aq$), and *picramic acid* ($C_{12}H_5(NO_4)_2NO_2$) when acted upon by sulphide of ammonium. All these acids form with bases salts that mostly are crystalline.

Phenic acid combines with the oxides of methyl, ethyl, and amyl to form:—

1. Phenate of methyl	$\left.\begin{matrix}C_{12}H_5O\\C_2H_3O\end{matrix}\right\}$
2. Phenate of ethyl	$\left.\begin{matrix}C_{12}H_5O\\C_4H_5O\end{matrix}\right\}$
3. Phenate of amyl	$\left.\begin{matrix}C_{12}H_5O\\C_{10}H_{11}O\end{matrix}\right\}$

1. Phenate of methyl or *anisol* is prepared by distilling anisic acid with caustic baryta. Its sp. gr. is 0·991. Boiling point 305·6° Fahr. By substitution it yields

Bibromphenate of methyl or bibromanisol .	$\left.\begin{matrix}C_{12}(H_3Br_2)O\\C_2H_3O\end{matrix}\right\}$
Nitrophenate of methyl or nitranisol . . .	$\left.\begin{matrix}C_{12}(H_4NO_4)O\\C_2H_3O\end{matrix}\right\}$
Binitrophenate of methyl or binitranisol .	$\left.\begin{matrix}C_{12}(H_3 2NO_4)C\\C_2H_3O\end{matrix}\right\}$
Trinitrophenate of methyl or trinitranisol .	$\left.\begin{matrix}C_{12}(H_2 3NO_4)O\\C_2H_3O\end{matrix}\right\}$
CHRYSANISIC ACID (isomeric with trinitranisol)	$\left.\begin{matrix}C_{12}(H_2 3NO_4)O\\C_2H_3O\end{matrix}\right\}$

The nitro-, binitro-, and trinitro-phenate of methyl yield the three following bodies by the action of sulphide of ammonium.

Methyl-phenidine or ANISIDINE . . .	$C_{14}(H_9)NO_2$
Methylnitrophenidine or nitranisidine . .	$C_{14}(H_8NO_4)NO_2$
Methylbinitrophenidine or binitranisidine .	$C_{14}(H_7 2NO_4)NO_2$

Sulphuric acid converts phenate of methyl into *methylsulphophenic acid* $\left(\left.\begin{matrix}C_{12}(H_4, C_2H_3)\ O\\ HO\end{matrix}\right\} S_2O_6\right)$ called also *sulphanisolic acid*, while anhydrous sulphuric acid transforms it into *sulphanisolide*.

2. Phenate of ethyl, *phenetol* or *salithol*, is prepared by submitting to distillation the perfectly dry compound of salicylate of ethyl with baryta. It is a colourless liquid, lighter than water, of agreeable aromatic odour, very soluble in alcohol or ether, but insoluble in water. It boils at 341·6° Fahr. Chlorine and bromine convert it into

crystalline products. Fuming nitric acid attacks and forms consecutively:—

Nitrophenate of ethyl or nitrophenetol .	?
Binitrophenate of ethyl or binitrophenetol .	$\left.\begin{matrix}C_{12}(H_3 2NO_4)O\\ C_4H_5O\end{matrix}\right\}$
Trinitrophenate of ethyl or picric ether .	?

Binitrophenate of ethyl yields *ethyl-nitrophenidine* or nitrophenetidine ($C_{16}(H_{10}NO_4)NO_2$) by the action of sulphide of ammonium.

3. Phenate of amyl or *phenamylol* is formed on heating a mixture of phenate of potash and iodide of amyl in a sealed tube to a temperature of about 220° Fahr. It is a limpid, colourless oil, of agreeable odour. Its boiling point is about 436° Fahr. Nitric acid strongly attacks it, and the resulting compound yields *amyl-nitrophenidine* by the action of sulphide of ammonium.

Oxyphenic acid. ($C_{12}H_6O_4$) *Binoxide of phenyl; pyrocatechin; pyromorintannic acid.* This body is a product of the dry distillation of CATECHU or of morintannic acid [TANNIC ACID.] The aqueous portion of the distillate is evaporated and set aside; the impure oxyphenic acid that deposits may be purified by recrystallisation from water, and finally by sublimation.

Oxyphenic acid crystallises in colourless rectangular prisms; it is very soluble in water or alcohol, but only slightly so in ether.

Trinitroxyphenic acid. ($C_{12}(H_3\,3\,NO_4)O_4$) *Oxypicric acid. Styphnic acid.* The composition of this body indicates it a derivative of oxyphenic acid, but the latter body does not yield it on being acted upon by nitric acid. It is most readily obtained by acting upon asafœtida or extract of Brazil-wood with nitric acid; many other gum-resins also yield it under similar circumstances. The liquid product of the action of nitric acid upon these bodies is neutralised with carbonate of potash and crystals of styphnate of potash obtained by evaporation; these may be recrystallised from a small quantity of boiling water or the styphnic acid precipitated by nitric acid. Brazil-wood extract furnishes about 18 per cent. of styphnic acid. It may be obtained in large yellow prismatic crystals from solution in alcohol. It combines with acids to form crystalline salts, called *styphnates* or *oxypicrates.* They all explode violently when gently heated.

Sulphites of phenyl. Hydride of phenyl dissolves in fuming sulphuric acid, and forms *phenylsulphurous* or *sulphobenzidic acid,* $\left.\begin{matrix}C_{12}H_5S_2O_4,\ O\\ H\ \ O\end{matrix}\right\}$. It may be looked upon as the hydrated oxide of the radical *sulphophenyl* ($C_{12}H_5S_2O_4$). It forms extremely stable salts with acids called *phenylsulphites,* or *sulphobenzidates.* Nitric acid converts it into *nitrophenylsulphurous* or *nitrosulphobenzidic acid,* $\left.\begin{matrix}C_{12}(H_4NO_4)S_2O_4,\ O\\ H\ \ O\end{matrix}\right\}$.

Chloride of sulphophenyl ($C_{12}H_5S_2O_4$, Cl) is a colourless oil, of sp. gr. 1·378, and boiling point 489·2. It is formed on distilling phenylsulphite of soda with oxychloride of phosphorus. It is readily attacked by ammonia, with production of *sulphophenylamide;* and the latter, by the ordinary process of substitution, yields the following primary, secondary, and tertiary monamides, including a tertiary diamide:—

Sulphophenylamide	$N\left\{\begin{matrix}C_{12}H_5S_2O_4\\ H\\ H\end{matrix}\right.$
Sulphophenylargentamide	$N\left\{\begin{matrix}C_{12}H_5S_2O_4\\ Ag\\ H\end{matrix}\right.$
Disulphophenylamide	$N\left\{\begin{matrix}C_{12}H_5S_2O_4\\ C_{12}H_5S_2O_4\\ H\end{matrix}\right.$
Sulphophenylsuccinylamide	$N\left\{\begin{matrix}C_{12}H_5S_2O_4\\ (C_8H_4O_4)''\end{matrix}\right.$
Sulphophenylbenzoylamide . . .	$N\left\{\begin{matrix}C_{12}H_5S_2O_4\\ C_{14}H_5O_2\\ H\end{matrix}\right.$
Sulphophenylbenzoylargentamide . . .	$N\left\{\begin{matrix}C_{12}H_5S_2O_4\\ C_{14}H_5O_2\\ Ag\end{matrix}\right.$
Sulphophenyldibenzoylamide	$N\left\{\begin{matrix}C_{12}H_5S_2O_4\\ C_{14}H_5O_2\\ C_{14}H_5O_2\end{matrix}\right.$
Sulphophenylbenzoylacetylamide . . .	$N\left\{\begin{matrix}C_{12}H_5S_2O_4\\ C_{14}H_5O_2\\ C_4H_3O_2\end{matrix}\right.$
Sulphophenylcumylamide	$N\left\{\begin{matrix}C_{12}H_5S_2O_2\\ C_{20}H_{11}O_2\\ H\end{matrix}\right.$
Sulphophenylbenzoylcumylamide . . .	$N\left\{\begin{matrix}C_{12}H_5S_2O_4\\ C_{14}H_5O_2\\ C_{20}H_{11}O_2\end{matrix}\right.$
Sulphophenylbenzolsuccinyldiamide . .	$N_2\left\{\begin{matrix}(C_{12}H_5S_2O_4)_2\\ (C_{14}H_5O_2)_2\\ (C_8H_4O_4)''\end{matrix}\right.$

Phenylide of sulphophenyl, or *sulphobenzide* ($C_{12}H_5S_2O_4, C_{12}H_5$), is also a product of the action of fuming sulphuric acid upon hydride of phenyl. Unlike phenylsulphurous acid, however, it remains insoluble when the product referred to is diluted with water.

Sulphate of phenyl $\left(\left.\begin{matrix}C_{12}H_5O\\ H\ O\end{matrix}\right\}S_2O_6\right)$. *Sulphophenic* or *phenylsulphuric acid.* A combination of phenic and sulphuric acids. It forms crystalline salts with ammonia and baryta.

Chloride of phenyl, or *chlorhydrophenide* ($C_{12}H_5$, Cl). A product of the action of oxychloride of phosphorus on phenic acid. It is an almost inodorous liquid, heavier than water.

Chloride of binitrophenyl, or *binitrochlorhydrophenide* ($C_{12}(H_3 2NO_4)$, Cl), is produced on acting upon binitrophenic acid with perchloride of phosphorus. It much resembles chloride of phenyl.

Aniline, phenylia, or *phenylamine* $\left(N\left\{\begin{matrix}C_{12}H_5\\ H\\ H\end{matrix}\right.\right)$, and its numerous interesting derivatives, will be found described in a separate article [ANILINE], or under ORGANIC BASES.

Cyanide of phenyl ($C_{12}H_5Cy$). *Benzonitrile.* Obtained by the distillation of dried benzoate of ammonia, as described under BENZOIC ACID. It a colourless oil, having an odour resembling that of bitter almond oil. It is soluble in alcohol or ether, but almost insoluble in water. Its sp. gr. is 1·0073; boiling point, 376° Fahr. Fuming nitric acid converts it into *cyanide of nitrophenyl* ($C_{12}(H_4NO_4)$, Cy), or *nitrobenzonitrile.*

PHENYL-PHTHALIMIDE. [NAPHTHALIC GROUP.]

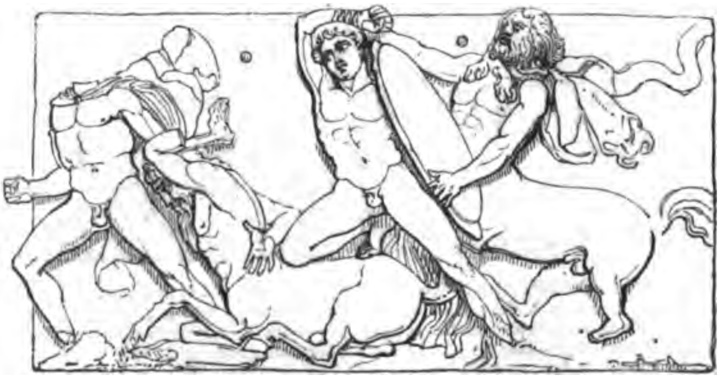
PHENYL-SULPHURIC ACID ($C_{12}H_6S_2O_8$). *Sulphophenylic acid.* A monobasic acid bearing the same relation to phenylic alcohol as sulphovinic acid sustains towards common or vinic alcohol.

PHENYL-SULPHUROUS ACID ($C_{12}H_6S_2O_6$). *Sulphobenzidic acid.* A crystalline organic acid, obtained by gently heating benzole with its own volume of sulphurous acid. Its salts are monobasic and very stable.

PHIAL, LEYDEN. [ELECTRICITY.]

PHIGALIAN MARBLES, a series of sculptures in alto-rilievo, preserved in the British Museum, which are so called from having been discovered among the ruins of a temple at the ancient Bassæ on Mount Cotylion, not far from the site of Phigalia. The subjects represented in them are the battle of the Centaurs and Lapithæ, which occupies eleven slabs, and that of the Greeks and Amazons, in twelve slabs.

Fig. 1.



The height of each is 2 feet 1 inch, and the whole length about 100 feet. These rilievi formed a frieze round the interior of the cella, and were elevated about 22 feet from the ground.

Pausanias (viii. 41), describing the edifice from which these marbles were brought, says, "After that at Tegea, it may be considered the most beautiful of all the temples of the Peloponnesus." The roof of the building was of stone. It was dedicated to Apollo Epicurius, or the *Deliverer,* a title conferred upon him because he had delivered the Phigalians from a pestilence.

These sculptures are of various degrees of merit as regards execution;

but the composition, expression, and style of art prove that they came from a fine school of design. The evidence of this in the works themselves is confirmed by the history (which has fortunately reached our times) of the temples which they decorated. The name of the architect was Ictinus, the same who, when Phidias was appointed to superintend the various public works carried on at Athens during the administration of Pericles, was associated with Callicrates to erect the Parthenon—one of the most splendid monuments of the golden age of art. This gives us the proximate date of the execution of the sculptures under consideration. The Parthenon was finished about 437 B.C. The temple of Apollo at Bassæ may therefore be attributed to about the same period.

Fig. 2.

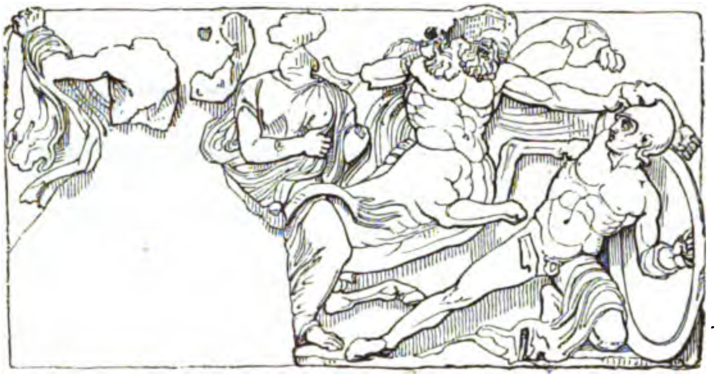


Fig. 3.

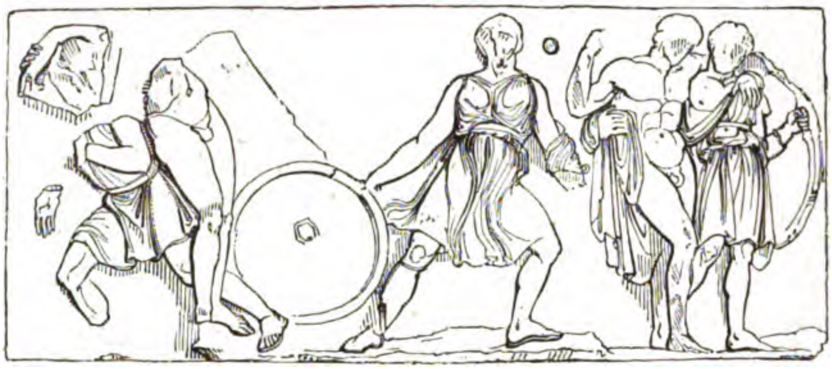


Fig. 4.

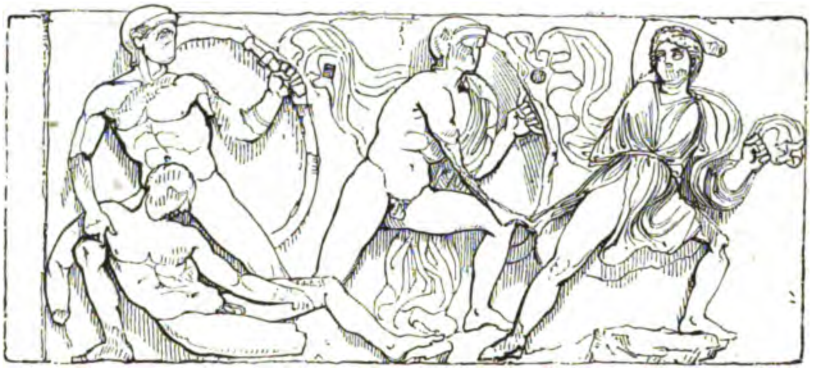
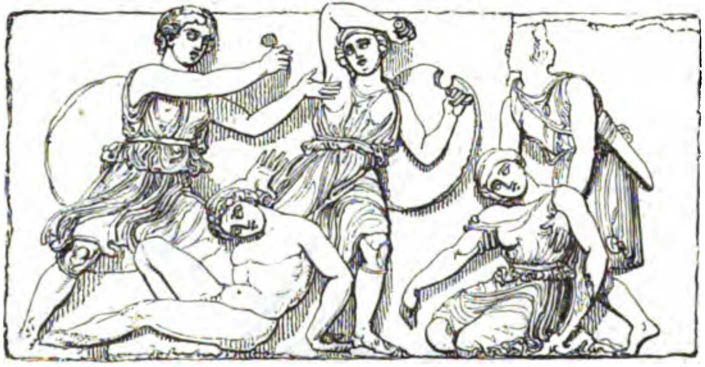


Fig. 5.



The quality of the design of these rilievi warrants the assumption that the eminent sculptor who directed the decoration of the former great work of Ictinus may have contributed the advantage of his skill by suggesting the fine compositions of the sculptures for his present undertaking. It is not difficult to discern in them the same sentiment and character which pervade the marbles of the Parthenon. This correspondence is particularly observable in comparing portions of the Phigalian frieze with the metopes of that building (see *figs.* 1 and 2 [Phigalian Marbles]; the third cut in the article CENTAUR, which is one of the Phigalian series; and *fig.* 1 under ELGIN MARBLES), where the same subject, the battle of the Centaurs and Lapithæ, is represented. The same may be remarked with respect to other parts of this fine series, whether it be considered for the energy displayed in violent action (*figs.* 1, 2, and 4; and the cut in the article CENTAUR), for grace and tenderness where gentler expression is to be conveyed (*figs.* 3 and 5), for playful flow of lines (as in groups in *figs.* 3 and 4), or for the just balancing of parts as the means of producing a harmonious whole. Throughout there is the stamp of careful thought, and evidence of an intimate knowledge of art, combined with a free and bold style. Among the excellencies of *treatment*, as it is technically called, the value and quality of flesh and drapery in contrast, are finely exhibited in parts of *figs.* 3 and 4. The few specimens here chosen for illustration are sufficient to show the claim these marbles have to our admiration as compositions. The difference alluded to in the merit of the execution may probably be owing to the working out of the general design having been entrusted either to pupils or to various and inferior artists, the idea and the compositions alone being furnished by the master-mind.

These interesting specimens of Greek sculpture were discovered in the year 1812. They were purchased for the British Museum in 1814, and arrived in England in the following year. The slabs were found, with two or three exceptions, lying on the floor or pavement of the temple, under the identical places they had originally occupied. They were much mutilated, both from the injury they had sustained from their own weight in falling, and from the heavy masses of the building which had fallen on them. They have been put together with great care, the pieces being secured by copper bolts; but in no instance has their integrity been impaired by restorations. For detailed descriptions of these marbles, the reader is referred to the elaborate work of Baron von Stackelberg, 'Der Apollotempel zu Bassæ in Arcadien,' &c., Rome, 1826; also to Part IV. of 'Description of the Ancient Marbles in the British Museum;' and to the 'Elgin Marbles,' in the 'Library of Entertaining Knowledge.'

PHILIPPIANS, EPISTLE TO THE, is one of the epistles written by St. Paul during his first imprisonment at Rome. [Paul, St., in Biog. Div.] Like the other early churches planted out of Palestine, the church at Philippi in Macedonia consisted of Jews and Gentiles, the latter forming the larger portion. These Philippians must, however, have had cultivated minds, and have been acquainted with the manners, customs, and philosophy of the Greeks, since the epistle contains allusions the force of which no other persons could fully understand. They were first converted by the preaching of St. Paul about twelve years before the date of this epistle, which was written apparently (ii. 24) but a short time before his release from his imprisonment at Rome, A.D. 63.

The occasion of its composition seems to have been the following: the Philippians, having heard that St. Paul was a prisoner at Rome, sent contributions for his relief by the hand of Epaphroditus, whom Theodoret and others represent as their bishop. St. Paul, being much rejoiced by this proof of their affection towards him, and by learning how great was their proficiency in all Christian excellences, sends back Epaphroditus with this epistle.

In this epistle, of which the canonical authority is incontestable, St. Paul discovers much of his own character, the traits of which cannot fail to create in the mind of an attentive reader an idea of true dignity. He delicately proposes his own conduct for the imitation of the Philippians; and, with no mixture of affected humility, he disclaims all personal merit for whatever wisdom or goodness they had seen in him or heard of him. His language is for the most part constructed with great skilfulness; his thoughts are arranged in an order exactly suited to his design; and his manner is at once affectionate and authoritative.

PHILIPPICS. [Demosthenes, in Biog. Div.]

PHILLIRIN ($C_{54}H_{34}O_{22}+3$ Aq.) A white crystalline substance of a silvery lustre found in the bark of the *Phillyrea latifolia.* It is inodorous, bitter, slightly soluble in cold water, moderately so in boiling water or alcohol, and nearly insoluble in ether. Boiled with dilute hydrochloric acid it is transformed into phillygenin (a resinous substance of the formula $C_{42}H_{24}O_{12}$) and grape sugar.

$$\underbrace{C_{54}H_{34}O_{22}}_{\text{Phillyrin.}} + 2HO = \underbrace{C_{42}H_{24}O_{24}}_{\text{Phillygenin.}} + \underbrace{C_{12}H_{12}O_{12}}_{\text{Grape sugar.}}$$

PHILO'LOGY (φιλολογία). It is difficult to attach a precise meaning to this word, as it is used in different significations by different writers. Among the Greeks and Romans, the term philology was originally used to signify a love for the investigation of all subjects connected with literature (Plat., 'Theaet.,' c. x. p. 146; c. xlvii. p. 161; Cic. 'ad Div.' xvi. 21; Ernesti, 'Clavis Ciceron.,' under φιλολογωτερα.) The Alexandrine critics applied the term philologus to a person who was well acquainted with the ancient Greek writers, and with the subjects treated of in their works; and we learn from Suetonius ('De Illustr. Grammat.,' c. 10), that Eratosthenes, who lived in the 2nd century before the Christian era, was the first who obtained this name, in consequence of his extensive and varied learning. In later times, a philologus was merely a person skilled in language, and the word became almost synonymous with grammaticus.

Some modern writers have included under the term philology the study of Greek and Roman antiquities, but the majority of writers appear to regard the study of the theory of language and of languages in general as the only subjects strictly belonging to philology.

The reader who wishes further information respecting the different meanings attached to the word philology, may consult Ast's 'Grundriss der Philologie,' Landshut, 1808; and the first essay in Wolf and Buttmann's 'Museum der Alterthums-Wissenschaft,' Berlin, 1807.

PHILOSOPHY, from the Greek *philosophia* (φιλοσοφία), literally signifies "love of wisdom or knowledge," and a philosopher (φιλόσοφος), is a "lover of wisdom." Pythagoras (Diog. Laert., *Proœm.*) is said to have first used the term philosophy, and to have called himself a philosopher, instead of a sophus (σόφος), or "wise man," for, he added, no one is wise but God. Among the Greeks, philosophy was sometimes viewed as comprising or consisting of three parts, physic (φυσικόν), ethic (ἠθικόν), and dialectic (διαλεκτικόν). Physic treated of the universe and that which it contained; ethic treated of things that concerned human life and man. The term dialectic is explained in the article Organon.

The terms philosophy, philosophical, philosopher, are often used in our own language apparently with no great precision, though it is not difficult to deduce from the use of these terms the general meaning or notion which is attached to them. We speak of the philosophy of the human mind as being of all philosophies that to which the name philosophy is particularly appropriated; and when the term philosophy is used absolutely, this seems to be the philosophy that is spoken of. Other philosophies are referred to their several objects by qualifying terms; thus we speak of natural philosophy, meaning thereby the philosophy (whatever that word may mean) of nature, that is, as the term nature is generally understood, of material objects. We also speak of the philosophy of positive law, understanding thereby the philosophy of those binding rules, properly called laws. The terms philosophy of history, philosophy of manufactures, and other such terms, are also used. All objects then which can occupy the mind may have something in common, called their philosophy; which philosophy is nothing else than the general expression for that effort of the mind whereby it strives, pursuant to its laws, to reduce its knowledge to the form of ultimate truths or principles, and to determine the immutable relations which exist between things as it conceives them. The philosophy which comprises within itself all philosophies is that which labours to determine the laws or ultimate principles in obedience to which the mind itself operates; and both those laws or ultimate truths, which must be considered as constituting the mind what it is, and which are therefore independent of all external impressions, and those laws by which the mind operates upon the sensuous impressions produced by objects which it conceives and can only conceive as being external to itself.

Thus every kind of knowledge, the objects of which are things external, has its philosophy or principles, which, when discovered and systematised, form the science of the things to which they severally belong. But inasmuch as the mind, in striving after this science, must act by its own laws and powers, and as these must in their form, viewed independently of their special objects, always be the same laws and powers (for we cannot conceive the mental powers to vary or differ in their essential qualities merely because they are applied to things that are conceived as different), we therefore assume that the mind has its laws and powers, which may be discovered by observation, as we discover by observation the laws or principles which govern the relations of things external to the mind, or conceived as external. Thus the human mind, by the necessity imprinted upon it, seeks to discover the ultimate foundation of all that it knows or conceives; to discover what itself is, and what is its relation to all things. Accordingly it strives to form a system out of all such ultimate laws or principles. Such a system may be called a philosophy, in the proper and absolute sense of the term, and the attempt to form such a system is to philosophise. Systems of philosophy have existed in all nations; even in the most uncivilised, in some form, and particularly in the form of a religion; for the highest aim of philosophy is to ascertain the relation of man to the infinite Being whom he conceives as the end and limit of all his inquiries. In nations which have made further progress in mental culture, the systems of philosophy are not limited to the dogmas of a religion, but those who have leisure, and whose minds have been disciplined, have in all ages ventured to transcend the limits of the religious system of their society or age, and to form what are called philosophical systems. The history of such systems is the history of philosophy, which thus viewed is a history of the progress of the human mind towards the knowledge of itself, a knowledge which, imperfect as it is, is the accumulation of many centuries, and the work of many contributors.

PHILOSOPHY OF THE HUMAN MIND. [Metaphysics.]

PHILOSOPHY, POSITIVE. The distinction of philosophy as positive and negative, was adopted by the German school. Thus Kant's 'Kritik der Reinen Vernunft,' his 'Prolegomena zu einer jeden Künftigen Metaphysik,' and his 'Kritik der Urtheilskraft,' are regarded as forming a sort of Prima Philosophia, preparatory to a positive or formal and detailed system of metaphysics. For though the philosophies which have successively arisen in Germany since Kant's day, such as the Scientific-doctrine of Fichte, the Transcendental Idealism of Schelling, the Phenomenology and Logic of Hegel, or the Metaphysic of Herbart, are all genealogically descended from Kant's Critical review (the review which reason was made by him to engage in, of the faculties of the soul), yet Kant himself, in his Kritik, did not profess to do more then pave the way for a system or dogmatik of speculative philosophy. Kant's main question proposed for solution in the criticism of reason was, "are metaphysics possible?" or, are synthetic judgments *à priori* possible?—judgments, or propositions, that is—the truth of which is not learned from experience, and which also are not merely analytical, or judgments in which the predicate barely unfolds the subject. Thus "all body is extended," is an analytical judgment: "all men are mortal," is synthetical indeed, but then it is *à posteriori*, being founded on experience: but, "every change must have a cause," is synthetical *à priori*, being universal and necessary, and founded in nothing but "pure understanding and reason." Now all such axioms, conceptions, and principles as are *à priori*, being enumerated, are regarded by those who make a distinction between positive and negative philosophy, as forming a negative philosophy, or as drawing the ground for a positive constructive system. Kant held out the expectation of such a system, as a superstructure to be erected by himself on the basis of the 'Kritik:' such a system of pure speculative reason I hope "to furnish myself, under the title, Metaphysic of Nature; which shall have far richer matter than this Kritik, though the latter was necessary, first to exhibit the sources and conditions of its possibility, and to cleanse and level a soil altogether overgrown with weeds." ('Kritik:' Vorrede.) Such a system would have been, in the German phrase, a positive philosophy: but the Transcendental Criticism professes only to examine and secure the foundation on which, the author says, "every future metaphysic" must be built, and is, relatively to such supposed system, merely negative.

The Positive Philosophy that Kant and the German metaphysicians only contemplated was at length propounded by M. August Comte, in his 'Cours de Philosophie Positive,' in 1830-1842, and his 'Discours sur l'Ensemble du Positivisme,' 1848. According to his system the human mind has passed through certain stages: the *theological*, in which supernatural agencies are necessary; the *metaphysical*, in which supernatural aids are dismissed, and their place supplied by abstract ideas. These stages he deems incorrect, and holds that the mind now arrives at the last and highest stage the *positive*, in which it grasps all that can be known with certainty, such as scientific truths, and holds that in other more complex subjects, such as Biology and Sociology (social science), definite laws prevail which may be ultimately discovered by strict observation and deduction, and that nothing is to be believed that cannot be proved. [COMTE, in BIOG. DIV.]

PHILTER (φίλτρον, *philtrum*), was a potion given among the Greeks and Romans to excite love. It is doubtful of what these potions were composed, but their operation was violent and dangerous, often depriving those who drank them of their reason. (Ovid, 'Ar. Amat.,' ii. 106.) Lucretius is said to have died from drinking a potion of this kind; and the madness of Caligula is attributed by some to a similar potion, which was given him by his wife Cæsonia. (Suet., 'Cal.,' 50; Juv., vi. 615, 616.) The most powerful love potions were prepared by the Thessalians, whence Juvenal speaks (vi. 610) of Thessala philtra.

PHLOGISTICATED AIR. An obsolete name for NITROGEN.

PHLOGISTON, an hypothetical substance, by supposing the existence of which Stahl [STAHL, in BIOG. DIV.] explained the phenomena of combustion. He imagined that by combination with phlogiston a body was rendered combustible, and that its disengagement occasioned combustion, and after its evolution there remained either an acid or an earth: thus sulphur was by this theory supposed to be composed of phlogiston and sulphuric acid; and lead, of the calx of lead and phlogiston, &c.

At this period, however, oxygen had not been discovered, and although Jean Rey had shown that metals by burning increased in weight, and Hooke and Mayow had attributed combustion to the presence of the air in which it occurs, yet the doctrine proposed by Stahl maintained its ground for about half a century. Soon after the discovery of oxygen gas by Dr. Priestley, the experiments which others had made on the calcination of the metals were repeated with great accuracy by Lavoisier; the consequence was, that the phlogistic theory gave way to the antiphlogistic; for the combustion, which had been attributed to the extrication of phlogiston, was known in all common cases to be derived from the absorption of oxygen, and this explained the increase of weight which bodies acquired by combustion, whereas on the phlogistic theory they ought to have suffered a diminution by the process.

PHLORETIC ACID. [PHLORIZIN.]

PHLORETIN. [PHLORIZIN.]

PHLORIDZIN. [PHLORIZIN.]

PHLORIZEIN. [PHLORIZIN.]

PHLORIZIN ($C_{42}H_{24}O_{20}+4$ Aq.) *Phloridzin*, a peculiar vegetable matter which exists in the bark of the trunk and roots of the apple, pear, cherry, and plum trees. According to Stass it is most readily obtained, and in large quantity, by treating either the fresh or dried roots of the apple-tree with weak alcohol at the temperature of about 150° Fahr. When the digestion has been continued for some hours, the clear solution is to be poured off, and the alcohol distilled; the residual liquor on cooling deposits phlorizin, which is to be rendered colourless by animal charcoal.

Phlorizin, when deposited from a saturated solution, has the form of silky tufts; but when obtained by the slow cooling of a dilute solution, it is in long flat brilliant needles. The taste of phlorizin is rather bitter, followed with slight sweetness; it is scarcely soluble in cold water, but boiling water dissolves it in large quantity; alcohol and pyroxylic spirit also readily take it up, and at all temperatures; ether, even when boiling, dissolves only traces of it, though, when mixed with alcohol, it dissolves it very well; it has no action on vegetable colours.

Phlorizin is by various processes, described by M. Stass, converted into *phlorizein* ($C_{42}H_{30}N_2O_{26}$), *phloretin* ($C_{30}H_{14}O_{10}$), *Phloroglucin* ($C_{12}H_6O_6+4$ Aq.), *Rufin* ($C_{42}H_{20}O_{16}$), *phloretic acid* ($C_{30}H_{12}(NO_4)0_{10}$?); for an account of these, we refer to his memoir contained in the 69th vol. of 'Annales des Chimie et de Physique.'

PHLOROGLUCIN. [PHLORIZIN.]

PHLORONE. ($C_{18}H_{14}O_2$) A yellow oil obtained by the dry distillation of camphorate of lime. It emits an odour like peppermint.

PHOCENIC ACID. [VALERIANIC ACID.]

PHOCENIN. Synonymous with VALERIN.

PHŒNIX (Φοῖνιξ), one of the most renowned of the fabulous monsters of antiquity, defined by the Arabians to be a "creature whose name is known, its body unknown." (Richardson's 'Arabic and Persian Dict.') The earliest author who mentions it is Hesiod (ap Plut., 'De Defectu Orac.,' cap. 11; and ap. Plin., 'Hist. Nat.,' lib. vii. cap. 49), who merely says that it lives nine times as long as a crow The first detailed description and history that we meet with is in Herodotus, whose words on that account deserve to be quoted at length. "There is also," says he, in his account of Egypt (lib. ii., cap. 73), "another sacred bird, the name of which is the phœnix; I have not myself seen it except in a picture, for it seldom visits them, only (as the people of Heliopolis say) every five hundred years. And they say that he only comes when his sire dies. And he is, if he is like his picture, of size and shape as follows: part of his plumage is gold-coloured, and part crimson; and he is for the most part very like to the eagle in outline and bulk. And this bird, they say, devises as follows, but they say what is to me beyond belief: that setting out from Arabia, he brings his sire to the temple of the sun; that he covers him with myrrh, and buries him in the temple of the sun; and that he covers him thus: first he forms an egg of myrrh as large as he is able to bear, and afterwards tries whether he can carry it; and when he has made the trial, upon this he hollows out the egg, and puts his sire into it, and covers with other myrrh that part of the egg where he had made the hole and put in his sire; and when his sire lies inside, the weight [of the egg] is the same [as it was before it was hollowed out], and having covered him up, he conveys him to Egypt into the temple of the sun. Such are the things which they say this bird performs." Such is the story as told in Herodotus, and it is substantially the same as what was afterwards, though with various embellishments, repeated and believed for more than a thousand years. It would be tedious and useless to quote the words of each author who forms the link in the chain: it will be sufficient to mention that between the times of Herodotus and Tacitus, the fable of the 'Phœnix' is told more or less fully and circumstantially by numerous classical writers. Of these writers perhaps the only passage curious enough to be particularly noticed is that in Lampridius, who tells us that Heliogabalus promised his guests a phœnix for supper; he was, however, obliged to be content with a dish of the tongues of phœnicopters (or flamingoes).

But it is not only in heathen authors that this fable is to be found; it is mentioned and believed by the Jewish rabbinical writers, and by the early fathers of the Christian church. The very words of several of these writers may be seen in Bochart (*loco cit.*); but the only rabbinical addition to the story worth noticing is preserved by Rabbi Osaia in his 'Berescith Rabba,' cap. 19 (ap. Bochart *loco cit.*), who says that the reason why the phœnix lives so long, and is in a manner exempt from death, is because it was the only animal that did not eat of the forbidden fruit in Paradise. A somewhat similar bird seems to have been known to the Arabians under the name of *Anka*. Mr. Lane, in the notes to his translation of the 'Tales of a Thousand and One Nights' (ch. 20, note 22), tells us, on the authority of Kaswini, that the anka is the greatest of birds; that it carries off the elephant as a kite carries off the mouse; that, in consequence of its carrying off a bride, God, at the prayer of a prophet named Handhalah, banished it to an island in the circumambient ocean, unvisited by men, under the equinoctial line; that it lives one thousand and seven hundred years; and that when the young anka has grown up, if it be a female, the old female bird burns herself; and if a male, the old male bird does so.

Many of the early fathers believed the story so firmly that they did not hesitate to bring it forward as a proof of the resurrection; and that, not as an *argumentum ad hominem*, when disputing with heathens, but seriously, and in writings addressed to converts to Christianity. St. Clement is the first who uses this argument (*loco cit.*), in which he is followed by St. Cyril and Tertullian (*locis cit.*), and Epiphanius ('Ancor.,' sec. 84, p. 89). The passage in St. Cyril (which also contains two or three additional embellishments) will serve as a specimen. "God knew men's unbelief," says he (in Mr. Church's translation, Oxford, 1838), "and provided for this purpose a bird called a phœnix. This bird, as Clement writes, and as many more relate, the only one of its race, going to the land of the Egyptians at revolutions of five hundred years, shows forth the resurrection; and this, not in desert places, lest the mystery which comes to pass should remain unknown, but in a notable city, that men might even handle what they disbelieve. For it makes itself a nest of frankincense and myrrh and other spices; and entering into this when its years are fulfilled, it evidently dies and moulders away. Then from the mouldering flesh of the dead a worm springs, and this worm, when grown large, is tranformed into a bird; and do not disbelieve this, for thou seest the offspring of bees also fashioned thus out of worms, and from eggs which are most moist thou hast seen the wings and bones and sinews of birds issue. Afterwards this phœnix, becoming fledged and a perfect phœnix, as was the former one, soars up into the air such as it had died, showing forth to men a most evident resurrection from the dead. The phœnix indeed is a wondrous bird, yet is irrational, nor sings psalms to God; it flies abroad through the sky, but it knows not the only-begotten Son of God. Is then a resurrection from the dead given unto this irrational creature, which knows not its maker; and to us, who ascribe glory to God and keep his commandments, shall there no resurrection be granted?"

Origen seems to doubt its truth ('Cont. Cels.,' lib. iv., cap. 98, p. 229), and Photius blames St. Clement for his credulity in mentioning it ('Biblioth.,' cod. 126, p. 305); but these two are (so far as the writer is aware) the only two of the ancient authors who did not believe it. This, however, ought not to lessen the authority of the fathers on other matters, nor should it be made a subject of reproach against them that "they were not proficients in a branch of knowledge which has been a peculiar study of modern times." (See Mr. Newman's preface to Mr. Church's 'Translation of St. Cyril,' Oxf., 1838.)

It would be almost impossible to enumerate all the more modern authors who, during the middle ages, expressed their belief in the existence of the phœnix, for the list would include almost all the writers on natural history, besides a great number of others. Perhaps the most curious circumstance relating to it is what is told us by Camden ('Britannia,' p. 783, ed. Lond., 1607), namely, that Pope Clement VIII. sent, in 1599, to Lord Tyrone, the chieftain of the Irish rebels, a phœnix's feather. This was mentioned in his work only eight years after the event took place, but we are not informed how the pope procured the feather, or what had become of it at the time when Camden wrote. Sir Thomas Browne, in his 'Vulgar Errors' (of which the first edition was published in 1646), thinks it necessary to state at some length his reasons for disbelieving the existence of the phœnix (book iii. ch. 12); and in 1552 he was attacked for this and other pieces of incredulity by Alexander Ross, in a work entitled 'Arcana Microcosmi, or the Hid Secrets of Man's Body discovered,' &c. With respect to the phœnix, the writer is not surprised at its seldom making its appearance, its instinct teaching it to keep out of the way of the tyrant of the creation—man; "for had Heliogabalus, that Roman glutton, met with him, he had devoured him, though there were no more in the world!" ('Arca. Micr.,' p. 202.) Alexander Ross, who was really a person of some sense and learning, was probably one of the last believers in the phœnix, which is now given up entirely to the poets; indeed, since the appearance of the 'Rejected Addresses,' almost abandoned even by them.

PHŒNIX, a southern constellation of Bayer, which may be best described as close to (but farther from the south pole than) the bright star in Eridanus (Achernar). Its principal stars are as follows:—

Character.	No. in Catalogue of (Piazzi) Lecaille. c.	No. in Catalogue of British Association.	Magnitude.
α	(69)	94	2
κ	(68)	93	4
λ	(94)	447	3
β	68 C	317	3½
δ	91 C	461	4
ε	1938 C	11	4

PHOSGENE GAS. [Chlorocarbonic Acid Gas.]

PHOSPHATES. [Phosphorus.]

PHOSPHIDES. [Phosphorus.]

PHOSPHITES. [Phosphorus.]

PHOSPHO-BERGAMIC ACID. [Bergamot, Essence of.]

PHOSPHO-GLYCERIC ACID. [Glycerin.]

PHOSPHORESCENCE. When phosphorus is exposed to the air it undergoes slow combustion, and emits a feeble light which is visible in the dark. Certain mineral substances emit a phosphorescent light when gently heated, such as phosphorite and chlorophane. The light however soon ceases and cannot be renewed until the body has been exposed to the sun, or to the electric flash produced by discharging a Leyden jar. Several kinds of sea fish become luminous soon after death, and the waters of the ocean frequently appear luminous from the presence of luminous animalculæ: this, however, is a subject which belongs to our Natural History Division—Luminosity of Organic Beings.

PHOSPHORIC ACID. [Phosphorus.]

PHOSPHORIC ACID, MEDICAL PROPERTIES OF. Dry phosphoric acid is sometimes used in the form of pills, but this is not an eligible mode; the common form is that of solution, constituting the dilute acid of the 'Pharmacopœia.' This differs from the other dilute mineral acids in not affecting so strongly the digestive organs, on which account it may be persevered in for a longer time. It is peculiarly suited to disordered states of the mucous surfaces, and also to states of debility, characterised by softening of the bones and a phosphatic condition of the urine. In this latter state it is often more efficacious when combined with iron, in the form of a phosphate of that metal; or better, the pyrophosphate. The same combination is of great utility in most cases of diabetes. In passive hemorrhages, phosphoric acid, properly diluted, quickly arrests the bleeding, as it coagulates the blood. This property is possessed in a stronger degree by the undiluted acid; and hence if injected into a vein, causes death. A poisonous dose of the strong acid may be counteracted by chalk, or carbonate of soda.

PHOSPHOROUS ACID. [Phosphorus.]

PHOSPHOVINIC ACID, *Ethyl-phosphoric acid.* [Ethyl.]

PHOSPHORUS. This elementary, solid, non-metallic body was discovered in 1669, by Brandt, an alchemist of Hamburg; he kept the mode of preparation for a long time secret, but as he could not conceal the fact of its being obtained from urine, Kunkel tried to procure it from the same source, and he succeeded in the attempt.

It will not be requisite to describe the original mode of preparing this very peculiar substance; therefore we shall only give an outline of the method at present employed. It has been shown that animal bone [Bone, in Nat. Hist. Div.] contains a large quantity of phosphoric acid combined with lime, forming a phosphate of that earth. It was first proposed by Scheele to obtain phosphorus from bones. For this purpose the bones are ignited or calcined in contact with air till they become white; when this happens it is a proof that the charcoal derived from the decomposition of the animal matter is entirely burnt off. In this state they consist of phosphate of lime mixed with little else than a small portion of carbonate of lime. After being reduced to a fine powder, they are mixed with sufficient water to form a thin paste, and digested for a day or two with two-thirds their weight of sulphuric acid. In this case sulphate of lime is formed, and the greater part of it remains insoluble, and a superphosphate of lime remains in solution; this is to be evaporated, and the precipitate formed being separated, the clear fluid, which is chiefly phosphoric acid, is to be evaporated nearly to dryness, and mixed with about a fourth of its weight of powdered charcoal; this mixture is to be strongly heated in an earthen retort, the beak of which is immersed in water; by the action of the heat the phosphoric acid yields oxygen to the carbon, and the results are carbonic acid or oxide, which is evolved in the gaseous state, and the vapour of phosphorus, which is condensed by passing into water.

The crude phosphorus thus obtained is mixed with wet sand and purified by redistillation from a large cast-iron retort, the neck of which just dips below the surface of water contained in a flat earthenware pan. The phosphorus is from time to time removed by an iron ladle and cast into sticks by fusing under warm water in a vessel that has a long glass tube attached to its lower part by a stopcock. The tube is surrounded by cold water contained in a tub, and at first its end is closed by a cork. On opening the tap the melted phosphorus flows into the glass tube, and when it has solidified, the cork is carefully withdrawn, and with it the rod of phosphorus, fresh liquid phosphorus continuing to flow in. By this means the whole of the phosphorus may be drawn out in one continuous stick of any required diameter, and coiled round in the tub or cut into pieces with scissors while still under water.

Phosphorus is solid, translucent, and nearly colourless; it is so soft that it may be indented by the nail, and it is very readily cut. When heated to 111·5° Fahr. it fuses, and at 550° is converted into vapour; it has a peculiar smell when exposed to the air, but this is probably derived from the action of the oxygen of the air upon it. Neither water nor alcohol dissolves phosphorus, but it is slightly dissolved by ether and by oils. It emits light when exposed to the air in the dark, and hence its name (from φῶς, *light*, and φέρειν, *to carry*). It is extremely inflammable, and has been known to take fire spontaneously in the atmosphere when the temperature was not above 60° Fahr. Its specific gravity is about 1·83. Phosphorus is also soluble by the aid of heat in naphtha, bisulphide of carbon, and dichloride of sulphur; on cooling from solution in the last-mentioned it has been obtained in dodecahedral crystals, and by mere fusion and slow cooling of a larger quantity, it has been procured in octohedral crystals.

Phosphorus may be *granulated* by fusing under alcohol, or in water containing a little urea, and well agitating till cold.

Amorphous, or *red Phosphorus* is an allotropic variety that has long been known to chemists, but has been extensively manufactured only since the year 1848. It is most easily made by keeping ordinary phosphorus for several days at a temperature of 450° or 460° Fahr. It forms a red or purple friable amorphous mass. Its specific gravity melting point and igniting point are higher than ordinary phosphorus. It is insoluble in bisulphide of carbon, is neither dangerously inflammable nor poisonous, and does not communicate to the workpeople engaged in handling it, that painful disease of the jaws that ordinary phosphorus imparts. These properties have secured for it extensive use in the manufacture of lucifer matches, and it was at one time hoped that it would quite supersede the white variety: unfortunately however, it gradually attracts oxygen from the air and the phosphorous and phosphoric acids produced are so exceedingly deliquescent that matches prepared with amorphous phosphorus are liable to become damp.

Black Phosphorus is another amorphous variety of this element. It is obtained by very suddenly cooling melted phosphorus.

The equivalent of phosphorus is 32.

Oxygen and Phosphorus combine with great readiness, and form four distinct compounds, namely:

1. Oxide of phosphorus	P_2O
2. Hypophosphorous acid	PO
3. Phosphorous acid	PO_3
4. Phosphoric acid	PO_5

1. *Oxide of Phosphorus.*—This is prepared by melting phosphorus in hot water, and in this state forcing a jet of oxygen gas upon it. The phosphorus burns under water, and the results are phosphoric acid, which remains in solution, and which we shall presently describe, and a red pulverulent body, which remains at the bottom of the vessel, and is the oxide of phosphorus. It is inodorous and tasteless, and is insoluble in water, alcohol, ether, or oil. It undergoes no change in the air, even when heated to above 600° Fahr.; but at a low red heat it burns. In chlorine gas it inflames. It decomposes nitric acid readily, and combining with its oxygen, becomes phosphoric acid. It does not possess either acid or alkaline properties.

2. *Hypophosphorous Acid* was discovered in 1816 by M. Dulong. When phosphide of barium is acted upon by water, both suffer decomposition, and there are formed phosphuretted hydrogen, phosphoric acid, hypophosphorous acid, and baryta; the earth combines with both the acids, and the phosphate of baryta being insoluble, is precipitated, while the hypophosphite is soluble, and sulphuric acid being added to the solution, sulphate of baryta is precipitated, and free hypophosphorous acid remains in solution; by evaporating this, a viscid strongly acid substance is obtained, which is hydrated hypophosphorous acid.

Hypophosphorous acid is liquid, uncrystallisable, has a powerful taste, is heavier than water, and cannot be obtained in a dry state. When subjected to the action of heat, it is quickly decomposed into phosphuretted hydrogen gas, which escapes, and phosphorous and phosphoric acids. Water dissolves this acid in all proportions; it acts very powerfully as a deoxidising agent, but nevertheless combines with many salifiable bases, forming salts which are termed *hypophosphites;* these salts are remarkably soluble in water; they are usually deliquescent, and crystallise with great difficulty. From the circumstance that neither this acid nor its salts can be obtained free from water, its true formula is probably PH_2O_3, that is phosphoric acid in which two atoms of oxygen are replaced by two of hydrogen.

3. *Phosphorous Acid*, like the preceding, is entirely an artificial product; it is obtained in the greatest purity by subliming phosphorus through bichloride of mercury in a glass tube. During the action of the heat, the phosphorus takes half the chlorine from the mercury, and they form a volatile compound which condenses into limpid liquid chloride of phosphorus: when this is mixed with water, mutual decomposition occurs; the hydrogen of the water and the chlorine of the chloride form hydrochloric acid, while the oxygen and phosphorus unite to form phosphorous acid. By evaporation the hydrochloric acid is expelled, and when evaporation has been continued until the residue, while hot, has the consistence of a syrup, it becomes a solid crystalline mass on cooling, which is hydrated phosphorous acid. This acid dissolves very readily in water, has a sour taste, reddens vegetable blue colours, and combines with some bases to form salts, which are called *phosphites.*

Phosphorous acid is also formed when phosphorus is burnt in rarefied air. When phosphorus is exposed to air and moisture, it has been long known that a dense sour fluid is formed by the absorption of oxygen: this was supposed by M. Dulong to be a peculiar acid, and he called it phosphatic acid; it was however subsequently shown by Davy to be a mixture of phosphorous and phosphoric acids.

Phosphite of Ammonia is procured by adding carbonate of ammonia to the acid to saturation. It crystallises in deliquescent needles; when heated, it is decomposed, giving out ammonia; and by the continued application of heat, the phosphorous acid remaining is converted into phosphoric acid. It is not a salt of any importance.

4. *Phosphoric Acid.*—This acid exists largely in nature, not only, as has been already mentioned, in combination with lime, forming bone, but also in some vegetable products, and often in the bowels of the earth, combined with lime, forming a mineral which, when crystallised, is frequently called *apatite.* [See also PHOSPHATITE, in NAT. HIST. DIV.] It also occurs in combination with oxide of iron, copper, lead, manganese, and uranium; but the quantity of these compounds is by no means large, and they are regarded chiefly as objects of curiosity.

Phosphoric Acid may be artificially formed by the direct combination of its elements. When a piece of phosphorus is inflamed, and immediately covered by a large bell glass, white flakes of phosphoric acid are produced, which fall like snow in the vessel. When exposed for a short time to the air, the acid deliquesces. So great is its affinity for water, that when collected, and a little water added to it, it is converted into a hydrate with explosive ebullition, owing to the heat which is evolved during combination. Phosphoric acid, when free from water, may be volatilised in a glass tube by the heat of a spirit-flame; the hydrate is even more readily dissipated.

Phosphoric acid is also formed when phosphorus is heated in moderately strong nitric acid; the nitric acid is decomposed, and yields oxygen to form the phosphoric acid. By evaporation in a platina capsule, hydrated phosphoric acid is obtained.

Phosphoric acid is colourless, inodorous, dense, extremely sour to the taste, and acts strongly on vegetable blue colours; it does not, however, like sulphuric acid, destroy the skin when applied to it. Phosphoric acid is peculiarly disposed to combine with different proportions of water, and these compounds exhibit properties so different, that they might be supposed to be three different acids, instead of different hydrates of the same acid. When the dry acid, obtained as described from the combustion of phosphorus, is thrown into water, a mixture of the three hydrates is obtained in variable proportions; but they may be separately obtained in a pure state from the common phosphate of soda of the shops, after it has been purified by solution and recrystallisation. Decompose a warm solution of this salt by means of a solution of acetate of lead, and wash the precipitated phosphate of lead, and then pass a current of hydrosulphuric acid through it while suspended in water. When the excess of hydrosulphuric acid has been expelled by heat, a very sour fluid remains, which is a *terhydrate of phosphoric acid* ($3HO, PO_5$).

This terhydrated acid is unalterable by boiling its solution or keeping it for any length of time. The class of salts which it forms are *phosphates,* which give a yellow precipitate with nitrate of silver ($3AgO, PO_5$). Common phosphate of soda contains, therefore, this terhydrated phosphoric acid.

Pyrophosphoric Acid.—Professor Clark, of Aberdeen, first discovered that when common phosphate of soda is heated to redness, it is completely changed in some of its properties, and after being dissolved in water, it affords crystals of a new salt, which he named *pyrophosphate of soda* ($2NaO, PO_5$). It gives a white precipitate with nitrate of silver ($2AgO, PO_5$), instead of a yellow one. If a solution of this salt be decomposed by one of acetate of lead, and the precipitated phosphate of lead be treated with hydrosulphuric acid as already described, and then evaporated in vacuo, over sulphuric acid, without the application of heat, the remaining solution is pyrophosphoric acid, consisting of $2HO, PO_5$.

Metaphosphoric Acid.—If equivalent proportions of ordinary phosphate of soda ($2NaO, HO, PO_5$) and terhydrated phosphoric acid ($3HO, PO_5$) be evaporated to dryness, a tribasic phosphate of soda is obtained, containing ($NaO, 2HO, PO_5$), and this, on being treated as the last, gives an acid liquor, containing the metaphosphoric or monohydrated phosphoric acid (HO, PO_5).

Glacial phosphoric acid is also in general mostly metaphosphoric acid. This hydrate is characterised by producing a white precipitate in solution of albumen, and in solutions of the salts of earths and metallic oxides; precipitates which are remarkable semifluid bodies, or soft solids without crystallisation.

Hydrogen and Phosphorus combine in three different proportions. When phosphide of calcium is thrown into hot water containing hydrochloric acid, a yellow powder precipitates, which is a solid phosphide of hydrogen, containing P_2H.

Phosphuretted Hydrogen Gas (PH_3).—This gas was obtained by Gengembre in 1783: it is procured by boiling phosphorus in a solution of potash, or in small quantity on bringing phosphide of calcium into contact with water. The gas which arises is spontaneously inflammable; and during its combustion there are formed water and phosphoric acid: it is colourless, and has a disagreeable odour resembling that of onions. Water dissolves about two per cent. of this gas; but the solution, unlike that of sulphuretted hydrogen gas, has no acid properties. It deposits solid phosphuretted hydrogen when exposed to light. The specific gravity of this gas, according to Dumas, is 1·761. Its spontaneously inflammable property is due to the presence of *liquid phosphuretted hydrogen* (PH_2). The latter may be separated by passing the freshly-made gas through a tube immersed in a freezing mixture. It burns explosively when exposed to the air, and renders hydrogen, carbonic oxide, &c., spontaneously inflammable.

Phosphuretted hydrogen gas decomposes some metallic solutions, such as those of copper and mercury, and metallic phosphides are precipitated. When it is pure, it is entirely absorbed by sulphate of copper and chloride of lime.

Chlorine and Phosphorus combine in two proportions, forming the pentachloride and terchloride.

Terchloride of Phosphorus (PCl_3).—When a mixture of bichloride of mercury and phosphorus is heated, we have already had occasion to notice that terchloride of phosphorus is produced. When first procured, it has generally a reddish colour, owing to the presence of a little uncombined phosphorus. When this has had time to deposit, or when it is purified by slow distillation, it becomes limpid and colourless. It has a suffocating odour, and fumes when exposed to the air. Its specific gravity is 1·616. It does not alter the colour of dry litmus-paper; but if moist, then hydrochloric and phosphorous acids are formed, which redden it strongly. The vapour of this compound is combustible, and acts with great energy upon water, producing the changes which have been described.

Pentachloride of Phosphorus (PCl_5) is obtained by the spontaneous combustion of phosphorus in chlorine gas; a white, flaky, volatile compound is formed, which is the perchloride. It is volatile, rising in vapour at 200°. It is fusible under pressure, and crystallises in prisms. It reddens dry litmus-paper, owing, as has been suspected, to its acquiring oxygen and hydrogen from the decomposition of the paper. Like the protochloride, it acts strongly upon and decomposes water; but the results are hydrochloric acid and phosphoric, instead of phosphorous, acid.

Phosphide of Nitrogen (PN_2?).—This compound cannot be obtained by direct action; it is the result of the action of ammonia on the chlorides of phosphorus. The changes which occur are effected with difficulty, but the phosphide of nitrogen eventually obtained has the following properties:—It is a light white powder, and, although formed of very volatile constituents, it remains fixed and infusible even at a red heat, when the access of air is prevented; but if that be present, white vapours of phosphoric acid are formed. This compound is remarkable, also, for its indifference even to the most powerful re-agents; it is insoluble in water and in acids, nitric acid even attacking it only after long continued exposure to it. Chlorine and sulphur do not act upon it; it is insoluble in alkaline solutions, but when heated with solid hydrate of potash, ammonia is evolved. According to Gerhardt, it contains hydrogen, and its formula is HN_2P.

Sulphur and Phosphorus may be made to combine in all proportions by fusion in an exhausted flask or under water; but the operation requires great caution. The resulting sulphides are very inflammable, and mostly crystalline.

Phosphorus and Iodine. [IODINE.]

Phosphorus and Bromine. [BROMINE.]

Phosphorus may be made to combine with the greater number of the metals; the most important of these compounds (*phosphides*) will be found under each particular metal.

Detection of Phosphorus.—Phosphorus is very poisonous. It is readily detected in a mixture containing organic matter by placing the suspected mixture in a flask, adding sulphuric acid, suspending a piece of paper streaked with solution of nitrate of silver from the upper part of the flask, and gently heating; if phosphorus be present, the paper will exhibit black marks of phosphide of silver. The absence of sulphuretted hydrogen, and of arsenic, must be previously ascertained; the one by acetate of lead paper suspended in the flask, the other by Marsh's test.

Detection and Estimation of Phosphoric Acid.—One of the best tests for phosphoric acid is the production of a white crystalline precipitate in the presence of ammonia, on the addition of a soluble salt of magnesia. The resulting ammonio-phosphate of magnesia, on being ignited, is converted into phosphate of magnesia, which contains 63·33 per cent. of phosphoric acid.

PHO'SPHORUS, MEDICAL PROPERTIES OF. This elementary substance exists as an essential constituent both of vegetable and animal bodies; yet when applied in a concentrated and pure state to any organised structure, it acts upon it as a violent and corrosive poison. Into animal bodies it is introduced in a diluted and combined state, by which it is disarmed of its virulence, as an ingredient of many common articles of food. One of the chief sources of it is the starch of the cereal grains, such as wheat-flour, in the ashes of which, when burnt, it amounts to 23 per cent. (Prout's 'Bridgewater Treatise,' book iii.); also alliaceous plants, such as onions, in which it exists as a phosphate of iron; polygonous and other plants, in which it occurs as a phosphate of lime. It also exists not only in the bones and other hard parts of animals, but in many of the fluids, especially the excretions. Thus it is found in the milts and roes of fishes, the substance of oysters, the yelk of eggs, in the liver, and also the brain, in which organ of the human being it amounts to from 2 to 2½ per cent.

Phosphorus is of all stimulants the most powerful and diffusible, but, on account of its activity, highly dangerous. Its poisonous action seems to be connected with its strong affinity for oxygen, by which it is converted into phosphorous and phosphoric acids. Hence when brought into contact with the animal tissues, it abstracts oxygen from them, and produces an eschar, resembling a burn: the phosphorus in this way loses weight and is absorbed, so that the exhalation from the lungs and the cutaneous perspiration are impregnated with the vapour, and, under certain circumstances, luminous. A very small quantity of solid phosphorus, even one grain and a half, has proved fatal. Solutions of phosphorus in oils, fixed or volatile, or in ethers, are still more active and dangerous. The vapour of phosphorus is accused of causing a peculiar affection of the jaw-bone in persons working much with it, such as manufacturers of congreve matches. This evil may be prevented by wearing a sponge before the mouth and nostrils, and the observance of great cleanliness, especially using a solution of soda for washing the hands. Acetate of potash is useful in the dysuria which follows poisoning by phosphorus.

Little use is made of phosphorus or its oleaginous solutions in medical practice in Great Britain, though in cases of extreme prostration of the nervous system it is not without its value.

In the event of a poisonous dose being taken, bland mucilaginous, not oily, fluids should be freely administered, followed by magnesia or chalk in boiled water.

PHOSPHURETTED HYDROGEN. [PHOSPHORUS.]

PHOTOGRAPHY is both an *art* and a *science*. As an art it enables us to draw, depict, or write by means of light. As a science it teaches us how to observe and to investigate the effects produced by light upon all natural bodies, whether animate or inanimate, mineral, vegetable, or animal. Its study as an art is of comparatively recent date, but the science had previously excited the attention of nearly all the most eminent investigators in modern science. The names of Davy, Wedgwood, Thomas Young, Wollaston, and the two Herschels in this country—of Scheele, Ritter, Seebeck, Berthollet, and Becquerel on the Continent—testify to this effect. Photography is worthy of special attention from the fact that it requires for its rational and thoroughly successful pursuit a knowledge of chemistry, optics, and physics generally, together with an amount of artistic taste and manual dexterity, such as must be useful not only for purposes of mental training, but under a variety of circumstances in actual life. The variety of its parts and aims gives it a special charm for those who like to have a pursuit admitting of both activity of mind and body; its processes are as much carried on out of doors as in close laboratories. Further it has this charm, that while it furnishes problems of the greatest interest and intricacy for the most advanced philosopher in optics or chemistry, it has its practical processes, which may be readily apprehended, and exercised for purposes of utility or recreation by those who are but little skilled in physical manipulations.

The history of photography has been so fully treated of by Mr. Robert Hunt, in his 'Researches on Light,' and in his 'Treatise on Photography,' and also by the Abbé Moigno, in his 'Repertoire d'Optique Moderne,' that we need not do here more than recapitulate in a brief manner the points of chief interest which they have given at greater length.

It may be well to say at the outset, that it was not till the year 1839 that Photography acquired for itself distinct recognition, through the investigations of Fox Talbot and Daguerre, which resulted in the introduction of the two processes known as the Calotype or Talbotype, and Daguerreotype. As usual in the history of art and science, approximations had been attained to by earlier experimentalists. It is interesting to inquire into the labours of some of these. Proceeding historically, we shall find that observations relating to the *science* of photography precede the first attempts at establishing the principles of the art.

In 1722 Petit noticed that solutions of nitrate of potash and muriate of ammonia crystallised more readily in the light than they did in darkness. In 1777 Scheele wrote, "It is well known that the solution of silver in acid of nitre, poured on a piece of chalk and exposed to the beams of the sun, grows black. The light of the sun reflected from a white wall has the same effect, but more slowly, heat without light being without effect." Again, "Fix a glass prism at the window, and let the refracted sunbeams fall on the floor. In this coloured light put a paper strewed with *luna cornua* (chloride of silver), and you will observe that this *horn silver* grows sooner black in the violet ray than in any of the other rays."

Senebier repeated these experiments, and also experimented on the influence of light in the bleaching of wax.

In 1798 Count Rumford sent to the 'Philosophical Transactions' a memoir entitled 'An Inquiry concerning the Chemical Properties that have been attributed to Light.' In this paper the Count attempts to prove that all the effects produced upon metallic solutions by bright sunshine are due to heat. In 1802 Mr. Harrup refuted this view, and showed that several salts of mercury were reduced by light alone, and not by heat.

In 1801 Ritter proved the existence of rays in the solar spectrum, which are to be found beyond its visible limits, and that these rays have the power of darkening chloride of silver. These researches having excited attention, MM. Berard, Seebeck, Berthollet, Sir W. Herschel, Sir H. Englefield, Wollaston, Davy, and others, made various experiments which tended still further to confirm the proof that light had a special influence over bodies beyond that exercised through its heat; and that the colour of the light was in some way related to this newly observed action of the sunbeam.

Before proceeding to notice the early efforts of those who laid the foundation of the *art* of photography, with which we are now to be chiefly engaged, we may observe that Priestley, Senebier, Ingenhousz, De Candolle, Saussure, and Ritter, directed attention to the influence of light upon plants—an interesting and important subject. Others followed in a similar track, still, however, leaving the matter in a comparatively obscure condition. The action of light on the human frame, and on animal life generally, has not yet been fairly investigated. That some special action will be detected there can be no doubt. We have long thought that light will come to be considered as important an element to health as fresh air and wholesome food. It may possibly be that much mental or bodily labour, exercised in the absence of the stimulus of daylight, is indirectly injurious to animal life.

But let us proceed to trace rapidly the *art* of photography to its source. In the Journals of the Royal Institution of Great Britain for 1802 will be found a paper by "Thomas Wedgwood and Humphry Davy"—the first a brother of the famous porcelain manufacturer, the second the Sir Humphry Davy of a later period. Their joint paper was entitled 'An Account of a Method of Copying Paintings upon Glass and of making Profiles by the Agency of Light upon

Nitrate of Silver; with Observations by H. Davy.' This paper contains the complete germs of the photographic art, namely, the application of an optical instrument to imprint upon a sensitive chemical surface the images of all natural objects illuminated by the sunbeam, or other source of light The instruments used by these observers were the camera obscura and the solar microscope: but let us first see how this important invention took shape in the mind of Wedgwood.

According to Davy, Wedgwood first commenced his researches with a view to copy the images of the camera obscura; and for this purpose, says Davy, "he first used nitrate of silver, which was mentioned to him by a friend as a substance very sensible to the influence of light." This nitrate of silver was applied in solution to surfaces of white paper and leather. "White paper or white leather," to quote the words of the memoir of 1802, "moistened with solution of nitrate of silver, undergoes no change when kept in a dark place; but on being exposed to the daylight, it speedily changes colour, and, after passing through different shades of grey and brown, becomes at length nearly black. The alterations of colour take place more speedily in proportion as the light is more intense. In the direct beam of the sun two or three minutes are sufficient to produce the full effect; in the shade several hours are required; and light transmitted through different-coloured glasses acts upon it with different degrees of intensity." . . . . "When the shadow of any figure is thrown upon the prepared surface, the part concealed by it remains white, and the other parts speedily become dark. For copying paintings on glass the solution should be applied on leather, and in this case it is more readily acted on than when paper is used. After the colour has been once fixed on the leather or paper, it cannot be removed by the application of water, or water and soap; and it is in a high degree permanent. The copy of a painting, or the profile, immediately after being taken must be kept in an obscure place; it may, indeed, be examined in the shade, but in this case the exposure should be only for a few minutes: by the light of candles or lamps, as commonly employed, it is not sensibly affected." No means were found to fix permanently the impressions thus produced. And, as regards the primary end of Wedgwood's researches, we are told that "The images formed by means of a camera obscura have been found to be too faint to produce in any moderate time an effect upon the nitrate of silver." Davy adds, "In following these processes, I have found that the images of small objects produced by means of the solar microscope, may be copied without difficulty on prepared paper. This will probably be a useful application of the method; that it may be employed successfully, however, it is necessary that the paper be placed at but a small distance from the lens."

The muriate (chloride) of silver was found to be more sensitive to light than the nitrate. "Even in the twilight, the colour of the moist muriate of silver spread upon paper slowly changed from white to faint violet; though under similar circumstances no immediate alteration was produced upon the nitrate." Davy concludes with these remarkable words: "Nothing but a method of preventing the unshaded parts of the delineations from being coloured by exposure to the day, is wanting to render this process as useful as it is elegant."

From this time the art in England slumbered until 1834, when Mr. Fox Talbot, without knowing what had been done, commenced experiments with the same end in view.

But we must now turn to a neighbouring country, France. In 1813, M. Niépce, of Chalons on the Saone, was engaged in a task identical in conception with that of Wedgwood. He was endeavouring, by means of bituminous varnishes and metal plates, to fix permanently the images of the camera, and he succeeded to a remarkable extent. His experiments were carried on until 1827, in which year he presented a memoir with specimens to the Royal Society of London; but, as he kept his processes secret, no notice was taken of his labours. Niépce returned to France dispirited. He there, however, continued his experiments, making pictures on a surface of bitumen laid upon a metal plate, which he afterwards engraved by ordinary engraver's acid. The rationale of his process is this:—Light is capable of hardening a bituminous surface in such a way that the usual solvents of bitumen no longer act readily upon the altered part of the surface, and therefore only the shaded portions of a partially illuminated plate would yield to such solvents as the mineral naphthas, for example, furnish. But when a metal plate had been partially laid bare by the removal of the bitumen in the shadows, nothing was easier than to etch such a plate by aqua fortis, and this was what Niépce did. A plate thus made and prints from it were in the possession of the late Mr. Robert Brown, of the British Museum. It is to be hoped that they are placed in the Museum itself. M. Niépce named his art *Heliography*.

In 1829 M. Niépce became acquainted with a M. Daguerre [DAGUERRE, L. J. M., in BIOG. DIV.], who was noted for his dioramic paintings, and who was, it is alleged, also engaged upon methods for fixing the images of the camera. A deed of partnership was executed between the two experimentalists, and they jointly pursued their labours until the death of Niépce, in July, 1833. A new arrangement was then made between his son, M. Isidore Niépce and Daguerre.

At length came the memorable year 1839, when the whole scientific and artistic world was startled at the announcement that objects could be made to draw their own pictures with an accuracy and minuteness quite unattainable by hand. In January, 1839, the first specimens by Daguerre were shown, but the process was withheld until the month of July. This enabled Mr. Fox Talbot to secure to himself the merit of priority of publication of a method by which sun-drawn pictures could be successfully produced. He, on the 13th of January, communicated to the Royal Society a paper, entitled 'Some Account of the Art of Photogenic Drawing, or the Process by which Natural Objects may be made to delineate themselves without the Aid of the Artist's Pencil.' And on the 21st of February in the same year, he gave another communication on the method of preparing sensitive paper and of fixing the images obtained. That the two experimentalists, Talbot and Daguerre, were independent discoverers is evident from the dissimilarity of their processes; the light and camera obscura being the only means strictly in common.

Mr. Talbot's method consisted in washing letter-paper over repeatedly with alternate solutions of salt and nitrate of silver; at a certain stage a surface was obtained which gave images under the influence of the camera, and these images were fixed by immersion in a strong solution of salt and water, in which the unaltered parts of the chloride of silver were soluble. This process was not very sensitive, and was therefore set aside by Mr. Talbot's later discoveries of 1840.

Let us now examine the nature of Daguerre's process called the Daguerreotype. A plate of silvered copper is highly polished, and then exposed to the vapour of the chemical element iodine, which imparts to the plate a series of colours, depending on the quantity of iodine absorbed. The exposure to the vapour was carried on until the plate assumed a rosy tint, or simply a deep orange-yellow, bordering on red. The plate was now sensitive, and had only to be exposed at the focus of the camera obscura in order to obtain a picture of any strongly illuminated object. Some minutes were necessary even in full sunshine. The plate was then withdrawn into the darkened room in which it had been prepared, and there it was exposed to the vapour of heated mercury, which has the wonderful property of attaching itself only to those parts of the iodised plate which have been exposed to light; and this deposit takes place in proportion to the original intensity of light of the image. Thus a picture was produced which represented in shades of black and white the original optical image seen on the ground-glass screen of the camera.

A solution of the hyposulphite of soda was used to fix the image by removing the compound of iodine and silver which still veiled in some degree the shadows on the plate. Subsequently M. Fizeau improved the appearance of Daguerreotypes by imparting to them a warm tinge by a thin film of gold which was thrown down upon the image by a spontaneous electro-chemical action.

The original Daguerreotype process was not sufficiently sensitive to be used in portraiture. To Mr. Goddard, who deserves reward, we owe the great improvement of the introduction of a second chemical agent, which now enables us to make pictures in a second of time. In 1840 Mr. Goddard combined bromine with iodine, and at once published the result in the 'Athenæum' journal. In the dull weather of November of that year, he obtained portraits in a few seconds; Daguerre's process requiring many minutes, even in a strong light. Mr. Claudet, at a later date, used chlorine with iodine for a similar end; but the bromine is still used in preference.

One of the best modes of procedure now adopted is the following:—Take a plate of silvered copper and polish it by means of tripoli powder and oil of lavender or rosemary, applied by cotton velvet, finishing the polish by *clean* cotton velvet alone. Then expose the silver to a mixture of iodine and pure sand in such a manner that the vapour of the iodine shall act equally upon the surface of the silver plate, to which it imparts a coating which is seen to be coloured when examined by light reflected from any white surface, a piece of paper for example. As soon as the plate has assumed an orange-yellow colour it is removed, and then exposed to the vapour issuing from a peculiar red compound of bromine with lime, called "bromide of lime." Over this it absorbs bromine, and assumes a rose tint; and as soon as this shade of colour has been obtained, the plate must be removed and again exposed to the iodine vessel until the rose colour has deepened into a plum tint. The plate is then ready for exposure in the camera obscura. No time can be stated for these various exposures, as temperature influences the results. A few seconds in each case suffice. The plate must be prepared in a room which can be darkened, the light of a candle, or that obtained through yellow glass, being alone used at the last iodising, and in some of the subsequent operations. After exposure in the camera, the plate is exposed to the vapour of mercury for a few minutes, the mercury being at a temperature of about 180° Fahr. Here the picture is developed by the action of the mercury upon the bromo-iodised surface, the mercury being, it is believed by some, deposited upon the plate in proportion to the amount of light which fell upon its surface during its exposure in the camera. On its removal from the mercury box the plate is partially fixed by washing its surface with a strong solution of hyposulphite of soda. The final fixation is effected by boiling upon the plate a solution of a double salt, called hyposulphite of soda and gold. The image is now fixed upon the plate, and may be coloured by brushing over it colours in very fine powder. The image should be kept so as to exclude the vapours of an impure atmosphere, such as is usually found in large towns. Sulphuretted vapours will at once darken the light part of the image. The film of stain may, however, generally be removed by a solution of cyanide of potassium. The Daguerreotype is still unsurpassed in delicacy of detail.

Having given an account of the Daguerreotype, we might proceed to relate the history of Mr. Fox Talbot's researches, which led to the invention of the first successful process in photography on paper; but as these will be found detailed in Mr. Talbot's work 'The Pencil of Nature,' and in the specifications of his patents, we prefer to pass at once to consider a process which has now almost superseded all others, and which certainly sprang out of Mr. Fox Talbot's discoveries. Mr. Talbot used iodide of silver with nitrate of silver in excess, upon paper, for the purpose of procuring an image which remained latent until developed by a solution of gallic acid. The process now used, and called the Collodion process, of Mr. Scott Archer, consists in the use of a film, on glass, of collodion, containing also iodide of silver with an excess of nitrate, the development being accomplished by pyro-gallic acid, or by sulphate of iron, the use of which we owe to Mr. R. Hunt, in the place of gallic acid. The analogy is complete, but the latter materials give a greater delicacy of result.

Collodion is made by dissolving in ether and alcohol cotton-wool which has been altered in its properties by treatment with strong acids. The following is a good mode of proceeding, and is due mainly to the researches of Mr. Hadow.* Take of pure nitrate of potash in fine powder 510 grains, of oil of vitriol (specific gravity 1·833 about) 15½ drachms, of water 1¼ drachm; stir together, and when at a temperature of from 150° to 155° Fahr. add, bit by bit, 15 grains of cotton-wool to each ounce of the acid mixture. Allow the cotton to soak for four or five minutes, and then wash it many times in water until it is quite free from acid. Then, to make the collodion, take 9 grains of the dry cotton, and add 6 drachms of pure ether (sp. gr. ·725 to ·730), and 2 drachms of pure alcohol (sp. gr. ·818 to ·820). The cotton should at once dissolve. In another bottle prepare what is called the "iodising solution," by taking alcohol (sp. gr. ·818 to ·820) one ounce, iodide of potassium 12 grains, iodide of cadmium 4 grains; dissolve the salts in the alcohol, and keep the solution for use. To make "iodised collodion," mix 6 drachms of collodion with 2 drachms of the iodising solution; this mixture changes by keeping, and should therefore be made only in moderate quantities. Having prepared the iodised collodion, a plate of glass is covered with it by pouring a quantity on the centre of the plate, and then allowing the liquid to flow to the corners in such a way that the glass shall be uniformly covered; the excess is then run off at one corner into a bottle set apart for the purpose. After a few seconds the film of iodised collodion is sufficiently firm to be fit for immersion (in the dark) in what is called the "nitrate bath." This bath is made by dissolving 30 grains of nitrate of silver in one ounce of distilled water. The nitrate of silver should be pure, and free from excess of nitric acid, and it should be saturated, when in solution, with iodide of silver: a little acetic acid, too, may be added. The plate is immersed in this bath for a few minutes, drained, and then exposed in the camera obscura. To develope the image, a solution of pyrogallic acid containing one grain of the salt to one ounce of water acidulated by 20 drops, or minims, of glacial acetic acid is poured upon the plate. If the image is not intense enough, a little weak solution of nitrate of silver must be added. The image obtained is fixed by a strong solution of hyposulphite of soda, in which it is immersed; or, instead, a weak solution of cyanide of potassium may be poured upon the plate, and left there until the yellow film of iodide of silver disappears. The plate is then washed and dried, and protected by a film of varnish, a spirit varnish being usually preferred for this purpose.

The picture thus obtained is, as in the calotype or Talbotype process of Mr. Fox Talbot, a *negative* one—that is to say, a picture having its light and shade reversed; though by modifying the collodion process *direct* positives may be at once obtained: a good negative, however, is a more valuable acquisition. In order to obtain copies correct in light and shade and position, a *positive* has to be made. There are many processes by which this can be done; but we will here give only one, which answers perfectly. Take the white of a fresh egg and beat up with every fluid ounce of it 12 grains of common salt: remove the froth thus obtained, and continue beating until all has become froth. Leave this froth to itself, and the greater part of the white of egg will become again liquid. Pour this liquid into a flat shallow dish, and upon it place carefully, so as to exclude bubbles of air, a sheet of thin paper (French paper is usually chosen); leave the paper for two or three minutes floating, so as to coat only one side with the "salted albumen," as the white of egg mixture is now called. Then carefully remove the sheet, and pin it up by a corner to dry. This operation can be carried on in daylight. To make this paper sensitive, it is floated upon a solution of nitrate of silver containing 100 grains of nitrate to one ounce of water. Here it is left for a minute, and then removed and suspended to dry. This last operation must be performed in a room lighted by yellow light, as in the case of the daguerreotype and collodion final preparation. Upon the dry paper the negative picture is placed face to face, and the whole exposed in a proper 'pressure-frame' to the sun or to daylight, or to the electric light for ten minutes or a quarter of an hour by night. After a few minutes the picture is found printed, and must next be fixed by immersion in a solution of hyposulphite of soda, one part of the salt in four parts of water. Ten or fifteen minutes' immersion would suffice to fix the picture; but in order to produce an agreeable tint of colour, a longer immersion is had recourse to, with the addition to the "fixing bath" of a few grains of a neutral solution of chloride of gold. After several hours' immersion in this bath, the picture is removed, and washed repeatedly with plenty of water; hot distilled water being used at last. This fixing bath is made fresh for each day's work. The pictures, when washed and dried, may be mounted on cardboard by means of starch, gum, or gelatine; paste is supposed to injure the picture under some circumstances. Exposure of the finished picture to *impure atmospheric vapours*, and to damp, is to be avoided. Mr. Malone has advised that the picture should be heated in a solution of caustic potash in order to secure its greater permanency. He also insists on the injurious action of sulphur in certain forms upon the print.

The process just described yields perfect results, and has superseded all others for the purpose of making 'Photogenic Drawings,' as they were formerly termed. Leaves, grasses, prints, feathers, lace, and indeed any well-defined object, translucent or not, may be depicted by simple contact with the prepared paper and subsequent exposure of the whole to light, under a sheet of glass pressed tightly on by springs or screws, as in the ordinary 'copying-frame.' In the absence of the sun, a quarter of an hour's exposure to the electric light will produce a good positive impression.

There is another branch of photography which is worthy of the attention of the student, but which has not yet come into practical operation in a perfectly satisfactory manner. It is that of photographic engraving. The labours of Niépce, Grove, Fizeau, Talbot, Pretsch, Poitevin, and others have done much to forward this art, and are well worthy of attention. Although the first Niépce laid the foundation of the art of Photographic Engraving, by his experiments on asphaltum, or Jew's pitch, it is to Mr. Talbot that we are indebted for opening up new processes in which organic substances such as starch, gum, albumen, and gelatine mixed with a salt of chromic acid furnish a photographic deposit which is capable of being worked by the ordinary processes of the engraver and lithographer. Mr. Talbot's plan is to pour upon a steel plate a mixture of bi-chromate of potash and gelatine, so as to obtain by drying a sensitive film: upon this film a positive photographic drawing is placed; now, by exposure to light, the gelatine becomes hardened, or nearly insoluble wherever the light has fallen through the positive picture. An engraving acid poured upon the plate will now etch only the shaded parts of the plate, and thus an engraved surface is obtained to be printed from with printer's ink. Mr. Pretsch, instead of etching the plate obtained by the action of the light on the gelatine compound, acts upon it by liquids; and what is most remarkable, gets a grained image in relief from which a mould is taken for the purpose of being electrotyped to form the copper-plate to print from. By proper manipulation, Mr. Pretsch can produce plates fit to print by the method called surface-printing, as with an ordinary wood block.

Of course, impressions taken from these plates by proper means can be conveyed to porcelain or glass, and burnt in by the enameller in the usual manner, or as at first devised by Mr. Malone, and described in a joint patent taken out with Mr. Talbot. To Messrs. Ponton and Becquerel we owe the first application of chromium to general photographic purposes. Mr. Pauncey and others have also devised ingenious processes by which pigments or inks may be made to adhere only to the altered gelatine and chromium compound surface, whether on paper, stone, glass, porcelain, or metals. These processes are as yet under trial. They lack the delicacy of tint of the albumen process, but they will doubtless yield ultimately valuable results.

Stimulated by the experiments of Sir John Herschel, M. Ed. Becquerel and others, M. Niépce de St. Victor commenced a series of beautiful experiments upon coloured flames and their photographic images. He laid before the Academy of Sciences, Paris, a detailed memoir upon the subject on the 4th of March, 1851. This was followed by others on June 2, 1851, Feb. 9, 1852, and November 6, 1852. By the method described in these papers, M. Niépce succeeded, he says, in obtaining upon silver plates which had been rendered sensitive by a chloride of copper, images which faithfully reproduced the colours in coloured engravings, flowers both artificial and natural, lay-figures dressed in stuffs and gold and silver lace, precious stones, &c. These were obtained both by the process of photographic printing and in the camera; the light and brilliant colours being obtained with comparative ease, but the darker and more sombre colours more slowly. The colours he rendered more vivid and at the same time more lasting by the action of ammonia. But beautiful as were the results, and much more nearly than in any other previous experiments as they seemed to approach the solution of the problem of photographing the colours of nature, they proved to be only comparatively permanent. The colours soon began to fade and eventually disappeared altogether. This method (due to M. Ed. Becquerel) M. Niépce named Heliochrome. M. Ed. Becquerel, by the use of silver plates, coated with a dark compound of chlorine and silver, obtained by the voltaic decomposition of hydrochloric acid, has succeeded in obtaining coloured images of the solar spectrum, but no method of fixing them permanently has been discovered.

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* See also Mr. Hardwich's formula in the 'Journal of the Photographic Society' for 1860.

In scientific photography much remains to be done. We know but little of the properties of light in its influence on vegetation and animal life. Mr. Robert Hunt and others have, however, established some interesting facts in the former direction, and lately some experiments made upon the eggs of insects seem to show that light of various colours and intensities acts differently according to its colour and other peculiar qualities. There is no branch of science which will better repay the philosophical experimentalist for his investigations than that of photography. The most marvellous and unexpected results have been constantly obtained.

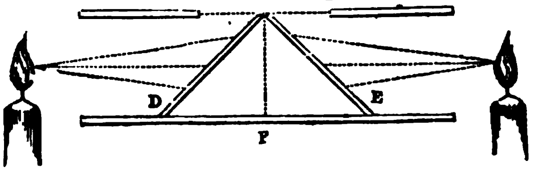
Those who would pursue photography further should consult Hunt's 'Researches on Light,' the Abbé Moigno's 'Répertoire d'Optique Moderne,' and Mr. Hardwich's 'Treatise on Photographic Chemistry.' There are many papers also of interest to be found in the 'Comptes Rendus' of the Paris Academy of Sciences, in our own Royal Society's 'Transactions,' and above all in the journals of the various Photographic Societies.

PHOTOMAGNETISM. A term sometimes applied to Dr. Faraday's beautiful discovery, by which the phenomena of magnetism have been placed in relation with those of light. [MAGNETISM.]

PHOTOMETER (literally "light-measurer," from φῶς and μέτρον), the name given to instruments constructed for the purpose of measuring the relative illuminating powers of different sources of light. When light or heat falls upon any substance, it is disposed of either by reflection, absorption, or transmission, or else by two of them, or all three of them combined. If two substances could be found which would reflect, absorb, and transmit calorific rays with the same intensity, and likewise reflect luminous rays equally, but differ in their powers of absorbing and transmitting light, we should then possess the means of at least ascertaining whether the absorption of light alone will produce effects analogous to what is observed to follow the absorption of heat. For this purpose it would be only necessary to prepare a differential thermometer whose bulbs were of the substances possessing the properties alluded to. The calorific rays accompanying the incident light would, by acting equally upon the two bulbs, produce no change in the indications of the instrument, and the only alteration, if any, which could ensue, would arise from the unequal absorption of light by the two bulbs. This alteration, however, when observed, though it might be considered a correct measure of the quantity absorbed, could not be taken for a measure of the quantity or brightness of the incident light, unless it could be further shown that the quantity absorbed by the same substance is proportional to the quantity of incident light, whatever may be its nature, that is, whether it be solar light, gas light, &c.

The photometer invented by Leslie differs from the instrument we have supposed, merely in its being in some respects less deserving of the name. It consists of a differential thermometer having one of its bulbs of plain transparent glass, the other of the same material coated either with Indian-ink or black enamel. Leslie remarks :—"The rays which fall on the clear ball pass through it without suffering obstruction; but those which strike the dark ball are stopped and absorbed at its surface, where, assuming a latent form, they act as heat. This heat will continue to accumulate till its further increase comes to be counterbalanced by an opposite dispersion, caused by the rise of temperature which the ball has come to acquire. At the point of equilibrium therefore the constant accessions of heat derived from the action of the incident light are exactly equalled by the corresponding portions of it again abstracted in the subsequent process of cooling. But in still air the rate of cooling is, within moderate limits, proportional to the excess of the temperature of the heated surface above that of the surrounding medium. Hence the space through which the coloured liquid sinks in the stem will measure the momentary impressions of light, or its actual intensity." Allowing that the light incident upon the clear ball is wholly transmitted, and that that which strikes the dark ball is wholly absorbed, assumes a latent form, and then acts as heat, it by no means follows that the effect produced upon the instrument was wholly or even chiefly attributable to the absorption of light, since we learn from Leslie's own experiments that the calorific rays which accompany the incident light would be more abundantly absorbed by the dark than by the light ball. This has since been so satisfactorily established by the observations of Thomson and others, that, as a measurer of light, the instrument may be regarded as useless.

The defects of Leslie's photometer were to a considerable extent obviated by the late Professor Ritchie, who, in 1825, communicated to the Royal Society the description of a new photometer. In order to intercept the calorific rays accompanying the light experimented upon, he transmitted the latter through a thick circular disc of glass into a metallic air-tight cylinder, the diameter of which was considerable compared with its depth. The axis of the cylinder was placed horizontally, and the aperture covered by the glass was the only one through which the light was admitted. Across the interior of the cylinder was stretched a circular sheet of dark paper, which absorbed the transmitted light, and, as was supposed, thereby converted it into heat, which became sensible by its expanding the air within the cylinder. A second cylinder of the same form and construction was placed by the side of the first so that the line of axes might coincide, but with the aperture for the admission of light turned in the contrary direction, and in that position they were connected by a bent thermometer tube containing a coloured fluid, which served to prevent the air of one cylinder from mixing with that of the other. So long as the air in the two cylinders possessed the same degree of elasticity, the level of the fluid in the two branches of the tube was of course the same; and a variation of level indicated a variation in the elasticity of the two bulks of air, arising from the more energetic action of the medium admitted through one aperture than through the other. To compare the relative intensities of two lights, the instrument was placed anywhere between them, and approached towards one or the other, until it was found that the position of the fluid in the tube was the same as when the instrument was not under the influence of the lights. Supposing the whole of the calorific rays and none of the luminous rays to have been intercepted by the glass, this position determined the point at which the intensity of the two lights was the same; and hence, since the intensity of light varies inversely as the square of the distance from its source [LIGHT], it followed that at equal distances from their respective sources their intensities were directly proportional to the squares of their observed distances from the instrument.



The same gentleman afterwards constructed a very simple instrument which affords a good measure of the relative brightness of two lights, provided they are of the same colour. The principle originated with Bouguer, who published it in his 'Traité d'Optique,' in 1760. The annexed figure represents a vertical section of the instrument. It consists of a rectangular box open at both ends and blackened upon its inner surface. On the top is a long narrow rectangular slip A B, covered with tissue or oiled paper. Within are two sheets of plane looking-glass, C D and C E, cut from the same slip to ensure uniformity of reflection. Each sheet has the same width as the box, and its length equal to the hypothenuse of a right angled isosceles triangle, whose side is the height of the box. Their reflecting surfaces are turned towards the open ends of the box, and their upper extremities rest against each other along a line, which in the figure is projected into the point C, and which divides the aperture A B into two equal parts, separated by a narrow strip of black card to prevent the mingling of the lights reflected from the two planes. In using the instrument it is placed between the lights whose intensities are to be compared, so that they may be reflected from C D and C E upon the tissue paper A B. It is then approached nearer to one or the other until, to an eye situated above A B, the two portions A C and B C appear equally illuminated, which, on account of the immediate proximity of A C and B C, may be determined with tolerable correctness, the colour of the two lights being supposed the same. The distances of the lights from the vertical C F being measured and squared, give the direct ratio of the intensities.

There is a mode of comparing the illuminating powers of two lights suggested by Count Rumford, which is remarkable for the facility with which it may be applied, and the simplicity of the requisite apparatus, nothing more being needed than a smooth surface of small extent and of a light uniform colour, and a blackened stick for throwing a shadow. The surface is illuminated by the two lights experimented upon, which are to be so placed, that when the stick is interposed between them and the surface, the two shadows may be nearly in contact, which will enable the eye to decide whether they are of equal depth, and will at the same time ensure the intercepting of rays equally inclined to the surface. So long as the shadows are of unequal depth, one of the lights must be brought nearer to or withdrawn farther from the surface till an equality of depth is obtained, and then the squares of the perpendicular distances of the lights from the surface give the ratio of their intensities. If an equality between the inclination of the intercepted rays to the surface cannot be obtained, then, when the two shadows are of the same depth, the intensities of the lights will be directly proportional to the squares of their perpendicular distances from the surface, and inversely proportional to the sines of the inclinations of the intercepted rays to the surface.

Suppose, for example, it were required to ascertain the illuminating power of a gas-light burning 5 cubic feet of gas per hour, as compared with that of a sperm candle burning 132 grains of spermaceti per hour; suppose the screen to be at 100 inches from the gas-light, and the candle only 27·75 inches in order to equalise the shadows. The relative intensities of the two lights are then found by squaring the distances of each light from the screen; the gas-light will diffuse a light which bears the same proportion to that of a candle as $100^2 : 27{\cdot}75^2$; or as 16 to 1.

Wheatstone's photometer consists of a small bright bead, to which a rapid looped motion is imparted, and this being placed between the two lights, both are seen reflected from the different points of the bead's surface. By the principle of persistence of impressions on the retina the two looped curves are seen of different degrees of brightness; the brighter light is to be removed until these curves appear of the same brightness, and the intensities of the lights are then as the squares of the distances as before. Bunsen's photometer consists of a compound disc of paper, of which the inner white disc is opaque, and the outer surrounding ring is made translucent by painting it with oil. When this is placed between the two lights, and viewed on one side, the opaque disc will be seen by reflection, and the translucent ring by transmission from the other light. The disc is then to be moved until both it and the ring appear to be equally illuminated, when the distances may be taken and squared as before. M. Babinet has contrived a polarising photometer. There are also photometers for measuring the relative brilliancy of the stars. These depend upon this principle:—that the brilliancy of the image of a star as seen through a telescope depends, *cæteris paribus*, on the size of the object-glass; by obscuring the outer rings of the object-glass the image of a star of high magnitude can be reduced to the light of a star of lower magnitude, as seen through the entire object-glass. The relative brilliancy of the two bodies may then be inferred from the diameters of the free object-glasses employed. In practice it is better to make use of two corresponding telescopes simultaneously. [STARS.]

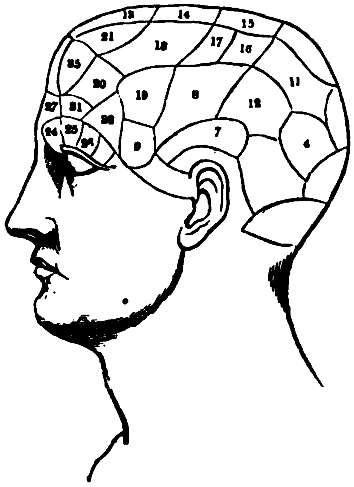
PHRASE, in music, a succession of sounds either in melody or harmony, expressing an unbroken sense more or less complete, and terminating in a pause (*repos*),—that is, a comparatively long note or a rest,—thus forming a cadence more or less perfect. Some authors have used the word *period* instead of phrase.

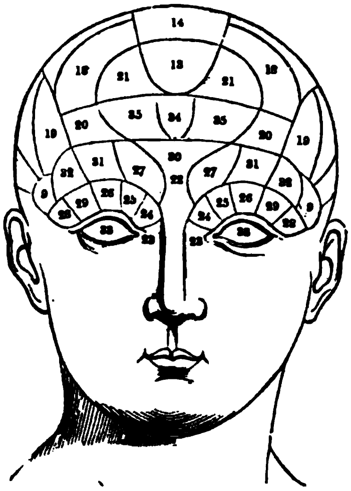
PHRENOLOGY (from φρήν, mind, and λόγος, discourse) is, in the words of Dr. Spurzheim, the doctrine of the special faculties of the mind, and of the relations between their manifestations and the body, particularly the brain. Without entering upon the question of the nature of the mind, or of the number or nature of its original faculties, it may be admitted as the result of all observation, and a fact on which nearly all physiologists are agreed, that the brain is the part of the body by means of which all the powers or faculties of the mind are manifested. The fundamental principles of phrenology, and those in which it chiefly differs from other psychological systems are, that the manifestation of each of the several faculties of the mind depends on a particular part of the brain, and that, *cæteris paribus*, the degree or strength in which each faculty is manifested in each individual, depends on the size of its appropriated portion of the brain, or (as it is termed) its organ.

The first principle, that of the plurality of organs in the brain, is supposed to be supported, 1, by the analogy of the other compound organs or systems in the body, in which each part has its special function; as, for example, in the digestive system, in which the stomach, liver, and other organs perform each their separate share in the common result of digestion of the food; 2, by the different degrees in which, in different individuals, the several mental functions are manifested. Even in the earliest period of childhood, and before education can be imagined to have exercised any influence on the mind, children exhibit the most varied dispositions—each presents some predominant propensity, or evinces a singular aptness in some study or pursuit; and it is a matter of daily observation that every one has his peculiar talent or propensity. But it is difficult to imagine how this could be the case, if the manifestation of each faculty depended on the whole of the brain; different conditions of the whole mass might affect the mind generally, depressing or exalting all its functions in an equal degree, but could not permit one faculty to be strongly and another weakly manifested. 3. The plurality of organs in the brain is supported by the phenomena of some forms of mental derangement. It is not usual for all the mental faculties in an insane person to be equally disordered; it often happens that the strength of some is increased, while that of others is diminished; and in many cases one function only of the mind is deranged, while all the rest are performed in a natural manner. 4. The same opinion is supported by the fact that the several mental faculties are developed to their greatest strength at different periods of life, some being exercised with great energy in childhood, others only in adult age; and that as their energy decreases in old age, there is not a gradual and equal diminution of power in all of them at once, but, on the contrary, a diminution in one or more, while others retain their full strength, or even increase in power. 5. The plurality of cerebral organs appears to be indicated by the phenomena of dreams, in which only a part of the mental faculties are at rest or asleep, while the others are awake, and, it is presumed, are exercised through the medium of the parts of the brain appropriated to them. 6. It is stated that the examination of the brains of individuals, each remarkable for some peculiar propensity or talent, has demonstrated a constant correspondence in the development of a certain portion of the brain; and that thus the results of the observations upon which phrenology was first founded by Dr. Gall, exactly coincide with and confirm the arguments by which its truths may, *à priori*, be made to seem probable. Lastly, pain has been felt in an organ when the faculty with which it is presumed to be connected has been greatly excited; and when a faculty has been morbidly manifested during life, disease has sometimes been found to have affected the corresponding part of the brain.

The preceding arguments for the existence, in the general mass of the brain, of several organs or instruments for the manifestation of the different powers of the mind, form also the basis of the rules by which those powers which may be called primitive, or original, are determined. Every power of the mind is regarded by phrenologists as a primitive faculty, and is considered to be manifested through the medium of a separate organ, which, 1, exists in one kind of animal and not in another; 2, which varies in the sexes of the same species; 3, which is not proportionate to the other faculties of the same individual; 4, which does not manifest itself simultaneously with the other faculties, that is, which appears or disappears earlier or later than they; 5, which may act or repose singly; 6, which individually is propagated in a distinct manner from parents to children; and 7, which singly may preserve its proper state of health or be affected by disease.

In accordance with these rules Gall enumerated nearly thirty primitive mental faculties, which are admitted, with more or less of modification, by all the phrenologists of the present day; and their number has been augmented by Spurzheim to thirty-five. These faculties Spurzheim divided into moral, or affective, and intellectual. The affective faculties or feelings he again divided into *propensities*, including all those which produce only desires or inclinations, and *sentiments*, including such as not only produce a desire to act, but are combined with some other emotion or affection which is not mere propensity. The intellectual faculties also he divided into the *perceptive* and the *reflective*. The subjoined figures and the references to them will at once indicate this division of the mental faculties, and the situations on the exterior of the head which are supposed to correspond with the portions of the brain belonging to each, according to the system of Dr. Spurzheim. We have also added the figures by which the several organs were marked by Mr. Combe, in the first and second editions of his 'System of Phrenology;' in the later editions he has followed the enumeration of Dr. Spurzheim.





1. *Amativeness* is the mental faculty which produces the propensity to physical love, or, as it was termed by Dr. Gall, the instinct of propagation.* Its organ is the cerebellum, and its energy is indicated by

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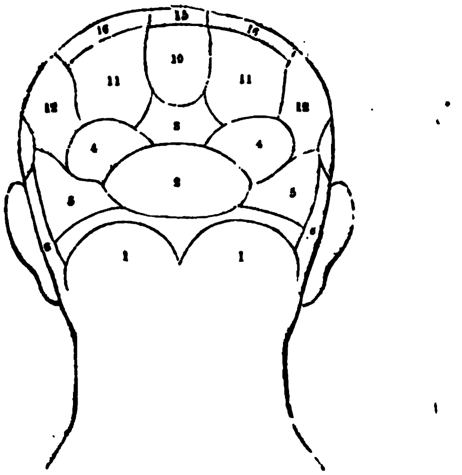
* It may be necessary to mention that the chief modifications introduced into the system of Gall by Spurzheim (whose arrangement is here adopted as being received by the great majority of phrenologists in this country) are expressed in the differences of their terms. Gall designated the organs according to the actions to which he believed their predominance led; Spurzheim according to the nature of the faculties. [See further, GALL; SPURZHEIM, in BIOG. DIV.]

the extent of the space on each side of the head between the mastoid process, immediately behind the ear and the spine of the occipital bone.



Combe.	Spurzheim.	AFFECTIVE.
		I. *Propensities.*
1.	1.	Amativeness.
2.	2.	Philoprogenitiveness.
3.	3.	Inhabitiveness.
4.	4.	Adhesiveness.
5.	5.	Combativeness.
6.	6.	Destructiveness.
9.	7.	Secretiveness.
8.	8.	Acquisitiveness.
7.	9.	Constructiveness.
		II. *Sentiments.*
10.	10.	Self-Esteem.
11.	11.	Love of Approbation.
12.	12.	Cautiousness.
13.	13.	Benevolence.
14.	14.	Veneration.
18.	15.	Firmness.
17.	16.	Conscientiousness.
15.	17.	Hope.
	18.	Marvellousness.
16.	19.	Ideality.
32.	20.	Mirthfulness or Gayness (Wit).
33.	21.	Imitation.

Combe.	Spurzheim.	INTELLECTUAL.
		I. *Perceptive.*
19.	22.	Individuality.
20.	23.	Configuration.
21.	24.	Size.
22.	25.	Weight and Resistance.
23.	26.	Colour.
24.	27.	Locality.
27.	28.	Calculation.
25.	29.	Order.
	30.	Eventuality.
26.	31.	Time.
28.	32.	Melody.
29.	33.	Language.
		II. *Reflective.*
30.	34.	Comparison.
31.	35.	Causality.

2. *Philoprogenitiveness* is the faculty which produces the feeling of love towards offspring. The evidence by which this is admitted as a fundamental faculty of the mind may afford an example of the application of the seven rules already given for determining them. There are many animals which take no care of their progeny, as reptiles and fish, and, among birds, the cuckoo. In many species of animals the females alone take care of their offspring, as among cats, cattle, sheep, &c., and in general, even when both parents protect their young, the attachment of the mother is the stronger. The love of offspring bears no proportion to the other mental faculties, but is shared alike by men and brutes, and among the former is often felt as intensely by the most degraded as by the most exalted of the species. The love of offspring is sometimes, on the contrary, almost completely suppressed. Cases of insanity have not unfrequently occurred in which parental love was lost or greatly diminished; while others are recorded in which the love of offspring has been almost the only feeling which remained unimpaired. The seat of this organ is directly above the middle of that of amativeness; and the energy of the faculty is indicated by the general protuberance of the occipital bone. Though placed in the middle of the head, this organ is of course, like all the others, double, and extends to an equal distance on each side of the median line.

3. *Inhabitiveness.*—The existence of this, the propensity to inhabit particular regions or countries, which produces the love of home, and which determines in each species the dwelling and mode of life which is best adapted to it, is regarded as doubtful. Dr. Gall placed in this situation the organ of pride in man, and that of the instinct in animals which prompts them to seek and inhabit the heights of mountains or to fly high in the air, believing that faculties which are merely physical in brutes may become moral in man, and that there is an analogy between the feelings which prompt to the pursuit of moral and those which excite the desire of physical elevation. Mr. Combe and many of the Edinburgh school of phrenology name this the organ of concentrativeness, believing that it corresponds to the faculty of maintaining two or more powers in simultaneous and combined activity, so that they may be directed towards one object, a faculty disposing to sedentary pursuits, and a close and steady attention, especially by meditation, to a given object. At present it is agreed that the evidence is insufficient for the complete establishment of either of these opinions.

4. *Adhesiveness* is the propensity to attachment or friendship, by which individuals of the same or different kinds are induced to associate together, and which causes men to be attached to the various objects amongst which they are placed. Its objects are disinterested friendship, marriage, society, and attachment in general. The organ of this faculty is believed to be situated at No. 4, immediately above and to the outer side of that of philoprogenitiveness.

5. *Combativeness* is the natural disposition which men and animals feel in various degrees to quarrel or fight. In order to discover its organ, Dr. Gall is said to have been in the habit of calling together boys from the streets to endeavour to make them fight. There were of course some who were fond of it, and others who were peaceable and timid: in the former the part of the head marked 5 was prominent; in the latter it was flattened or depressed. The same difference is said to exist in the formation of this part, in correspondence with the strength of this disposition in the several species of animals, and remarkably in the different varieties of dogs.

6. *Destructiveness*, or the propensity to destroy, is the feeling which is gratified by any kind or mode of destruction. Spurzheim ascribed to it the tendency to all kinds of destruction, whatever were their objects, or the mode in which they were effected. Thus defined, the propensity to murder is but one of the directions which the disposition for destruction may take, and one from which in a conscientious and benevolent man it would always be diverted. In such a man this propensity will be exercised for an innocent or even a useful end, as the procuring of food by the slaughter of animals, &c.; in another, in whom its influence is less counterbalanced, there will exist an indifference to the suffering and calamities of others, or even a positive pleasure in beholding or contemplating them; in a third, in whom it is unrestrained, it may break out in acts of violence and love of blood-shedding in every form. In the diseased condition of its organ this propensity is regarded as the source of the irresistible desire for the destruction of life, of which so many lamentable examples are known, and which is commonly called homicidal monomania. The seat of the organ of destructiveness is on each side of the head immediately above the ear, at No. 6; and its various degrees of development may be seen in a comparison of the width at this part of the heads of carnivorous and herbivorous animals.

7. *Secretiveness* is the propensity to act in a clandestine manner; to conceal emotion, and to be secret in thoughts, words, things, and projects. Its most frequent bad results are cunning and hypocrisy; and the most usual direction which it takes for good ends is prudence. The organ of this propensity is immediately above that of destructiveness, at No. 7. (In the casts made in accordance with the enumeration of the faculties employed by Mr. Combe, in the early editions of his 'System of Phrenology,' this organ is marked 9.)

8. *Acquisitiveness* is the propensity to acquire. Its organ being found very large in notorious thieves, Dr. Gall conceived that there was a natural disposition to theft. Dr. Spurzheim, on the other hand, makes no limitation as to the purpose or mode of acquisition, which he believes to be determined in each case by the degrees in which the several other faculties are developed. Variously modified, the propensity leads in some to the prudent accumulation of property by honest means; in others, to avaricious and purposeless money-making by any method; in others, to theft or fraud. The seat of its organ is at the back part of the temples.

9. *Constructiveness* is the faculty which leads to construction of all kinds: guided by it birds build their nests, rabbits burrow, beavers make their huts; and men are directed by it to manufactures, the practice of the several branches of the fine arts, building, and various manual operations. Its organ is situated at the lower part of the temple, at 9.

10. *Self-esteem* is the sentiment which gives an individual a high opinion of himself, which in excess produces pride and arrogance, and when moderate and modified by other superior faculties imparts dignity to the mind, and renders it hostile to everything that is mean or degrading. In a state of derangement the morbid excitement of this faculty leads the insane to imagine themselves exalted to thrones or to divinity. The seat of its organ is at the middle of the upper and back part of the head (10), directly above inhabitiveness (3), with which Dr. Gall (as already mentioned) confounded it.

11. *Love of Approbation*, according to Dr. Spurzheim, is the sentiment which makes us regard the opinion entertained of us, and induces the question—What will the world or the people say? It is fond of approbation in general, without attending to the manner of acquiring it; and may therefore be directed to objects of the highest importance, as well as to such as are of no moment, or are even hurtful. Ambition is the distinguishing epithet of its agency, if the subject aspired to be of great importance; vanity, if claim be laid to distinction on the score of trifles. The organ is seated on each side of self-esteem; when much developed it generally elongates the upper and back part of the head, but is sometimes spread out laterally so as to widen rather than lengthen it.

12. *Cautiousness* is the disposition of the mind which leads a man or an animal to take precautions in whatever he has to do; "it doubts, says *but*, and continually exclaims, *take care*" (Spurzheim). When too

active it causes irresolution, anxiety, and melancholy. Its organ is situated on the upper lateral and posterior part of the head, between destructiveness and self-esteem.

13. *Benevolence* is the disposition of the mind from which result compassion, kindness, philanthropy, mildness, charity, and various other amiable social virtues. Its existence as a fundamental power of the mind is considered to be proved by the rules above mentioned, and by which, it may be again observed, the existence of all the preceding and following faculties is determined; the seat of its organ is the upper and middle part of the forehead, just where the hair begins to grow.

14. *Veneration.* The organ of this faculty was called by Dr. Gall the organ of religion, and he believed that the disposition to the worship of God was directly proportionate to its development. Dr. Spurzheim has here again extended the scope of the faculty, by making it the cause of veneration or respect in general, whether directed to divine or human beings, or to inanimate objects. When the organ of this sentiment is much developed, the head is remarkably elevated; and it was by observing (as Lavater had before done) this peculiarity in the shape of the heads of very pious persons, that the position of the organ on the front part of the top of the middle of the head was determined.

15. *Firmness* is the faculty which gives constancy and perseverance to the other powers, and contributes to maintain their activity. In its various combinations with other faculties, the results to which it leads differ considerably: with much self-esteem and love of approbation, it produces an obstinate persistence in the pursuit of honour and rank; with benevolence, it excites the most active and persevering philanthropy; with destructiveness and acquisitiveness, it may excite to daring acts of murder and rapine. When, on the other hand, this faculty is little developed, it leaves men inconstant, and makes them the mere creatures of circumstances. Its organ is situated at the very top of the head, at 15.

16. *Conscientiousness* is the fundamental and innate sentiment which disposes mankind to look and to wish for justice. The existence of this feeling in a high degree is one of the chief constituents of a noble mind, and the strongest foundation of morality; its deficiency leaves men with little restraint to prevent them from following the impulses of all their worse propensities, and from striving to attain their ends by the most unworthy means. The situation of the organ of conscientiousness is on the upper part of the head, on each side of that of firmness.

17. *Hope* is the sentiment which induces men to believe in the possibility of whatever their other faculties desire; it is not mere desire, for that may continue without any expectation of being ever gratified. The different degrees in which it is developed will lead one person to be continually building, as it is said, castles in the air, and another to despair of success even in favourable circumstances. It is this sentiment, also, which inspires the hope of a future state and of immortality. Its organ is situated on each side of that of veneration.

18. *Marvellousness,* or *wonder,* is the sentiment which is principally manifested by a belief in miraculous and supernatural circumstances, and which leads men to be amused with everything that can excite their surprise and wonder. Its organ is situated immediately in front of that of hope.

19. *Ideality.* Dr. Gall regarded the organ of this faculty as the organ of poetry, finding it much developed in all the great poets of ancient and modern times. But it is also large in some who, though they may be fond of poetical conceptions, are not poets themselves. Dr. Spurzheim therefore believes that the essential nature of this sentiment is to impress a peculiar character called poetical or ideal, and to vivify the other faculties; to give a sense and love of beauty; to produce sublimity of conception, and excite warmth of imagination and expression. The organ of this sentiment is placed by the side of marvellousness, and the two frequently act together.

20. *Mirthfulness,* or *Wit.* Spurzheim regards this faculty as affective, not as intellectual, in which view it is considered by Gall, and by the principal phrenologists of the Edinburgh school. He describes it as a sentiment which disposes men to view everything in a gay or joyful manner, and which, according to its various applications in different circumstances, and its modifications by being variously combined with other faculties, produces wit, good humour, caricature, mockery, irony, sarcasms, epigrams, and satires. Its organ is situated in the upper and lateral part of the forehead, and in the earlier Edinburgh casts is marked 32.

21. *Imitation.* Those who have this faculty highly developed are fond of acting, and of imitating the gestures, voices, manners, and in general all the manifestations of man and animals. It is generally more active in children than in adults: the former always learn a great deal by imitation; of the latter, some only employ it much, and these are usually marked by the gestures with which they speak, imitating the habits and manners of whatever forms the subject of their conversation. Its organ is situated at the front of the head, and on each side of benevolence.

22. *Individuality* is, in Spurzheim's arrangement, the first of those intellectual faculties which perceive the existence of external objects and their physical qualities. It is the faculty which recognises the existence of individual beings. It is this, also, which in excess induces men to personify everything of which they speak, whether mere qualities or abstract ideas, or even phenomena, such as motion, life, the passions, &c. Its organ is situated behind the root of the nose, and its greater development enlarges the forehead between the eyebrows.

23. *Configuration,* or *Form,* is the power which takes cognisance of forms and figures generally. One of its peculiar applications, and that by which its organ was first discovered by Dr. Gall, is observed in the power which some individuals possess of remembering the forms and features of different persons; another is shown in the love of portraits, or in the ability to take the likenesses of persons and things. Its organ is situated in the internal angle of the orbit, and when large it pushes the eyeball outwards and downwards, giving the person in whom it is thus developed a somewhat squinting appearance, and making his eyes appear unusually wide apart.

24. *Size.* This is the faculty which measures the size of bodies, as distinguished from their form, which is appreciated by the preceding power. Its organ is placed at the inner corner of the arch of the eyebrow.

25. *Weight.* It is believed that the mind estimates the weight and resistance, as well as many of the other qualities of bodies, not by the sense of feeling, but by a peculiar internal operation, which must require a special organ. Dr. Spurzheim conjectures that its situation is behind the orbit, in the neighbourhood of configuration and size.

26. *Colouring.* There appears to be a peculiar faculty for the full appreciation of the relations of colour. For though few are incapable of perceiving the differences of colour in the objects around them, yet all have not the same power in this respect, nor have all the same facility in recollecting or judging of their relations. Many artists who draw well cannot colour; others are good colourists, but cannot imitate or design forms. The organ of this power, which must from these and other similar circumstances be regarded as an original faculty of the mind, is placed in the middle of the arch of the eyebrow.

27. *Locality.* This is the faculty by which we appreciate and remember the places occupied by objects around us; the mental power which makes the traveller, geographer, and landscape-painter; which recollects localities, and gives notions of perspective. It is remarkably shown in the power which many animals exhibit in tracing their way through great distances in migration, or in returning to their homes; and it gives men the propensity to travel, which many have so remarkably exhibited. Its organ is placed above and on each side of the root of the nose.

28. *Calculation,* or *Number,* might be called the faculty of arithmetic; whatever concerns calculation or number belongs to it, and hence Mr. Combe and many others speak of its organ as that of number. In those in whom the power of calculation is much developed, the external angle of the eyebrow is either much pressed downwards or elevated; the organ of this faculty being situated beneath that part of the brow.

29. *Order.* It is believed that there is a faculty which gives a disposition to arrange and put things in order; as, for example, in a library to place books according to their size and form; in a collection of natural history to make each subject occupy its right situation according to its configuration, or colour, or size. Cleanliness also seems to depend on it; and it produces the pleasure of seeing things complete. Its organ is situated between those of colouring and calculation.

30. *Eventuality.* Individuals who have this organ large are attentive to all that happens around them, to phenomena, to events, to facts; they are fond of history and of anecdotes; are inquisitive, and desire information on every branch of natural knowledge. Individuality takes cognisance of things which are, the names of which are nouns; and eventuality, of things which happen, the names of which are verbs. The organ is situated in the middle of the forehead, and those in whom it is much developed have a peculiar prominence of this part of the skull.

31. *Time.*—The faculty of time conceives the duration of phenomena, their simultaneousness or succession. Its organ is situated above the middle of the eyebrow.

32. *Melody or Tune.*—The organ of tune bears the same relation to the ears as that of colour does to the eyes. The ear is the instrument by which sounds are heard, but it has no recollection of them, and does not judge of their relations; these are the offices of a peculiar and original mental power, whose organ is above the outer part of the eyebrow, so that when much developed, it enlarges the lower and lateral part of the forehead.

33. *Language.*—This is the faculty which makes us acquainted with arbitrary signs, which remembers them, judges of their relations, and gives a disposition to indulge in all exercises connected with words. Its organ was the first that Dr. Gall discovered: in his youth he observed that while he had great difficulty in committing his lessons to memory, there were many boys who could easily learn by heart even things which they did not understand so well as he did. He noticed that all these boys were "bull-eyed," that is, had a peculiar prominence of the eye-ball, which seemed to project from its socket. Subsequent observation enabled him to confirm the opinion that the organ of verbal knowledge is situated at the very back part of the orbit, which is, with the eye, pushed forward by it when it is much developed.

34. *Comparison* is the reflective faculty which compares the sensations and ideas excited by all the other faculties, and points out their difference, analogy, similitude, or identity. It induces men to argue from analogy, to draw illustrations of their subjects from things well known, to speak by parables, and explain by examples and similes. It leads to the invention and employment of figurative language, and according to the degree of its national development, the language of each country will be full of or deficient in figures and metaphors. Its organ is situated in the middle of the upper part of the forehead.

35. *Causality.*—The reflective faculty which engages men in the study of the causes and origins of things, and which guides to the employment of processes of induction, is thus named. The faculty of individuality makes us acquainted with objects; eventuality, with facts; comparison, with the analogy, identity, difference, and other relations of things; and causality leads us to search for their causes: together, these faculties, when fully developed, constitute the truly philosophic mind. The organ of causality is at the upper part of the forehead, on each side of comparison, and their coincident development gives the peculiar fullness of the front of the head, which is universally regarded as the sign of a powerful reasoning intellect.

Having now given a general view of the principles of phrenology, as stated in the writings of Dr. Spurzheim, and adopted by most of the present advocates of the system, it will probably be desirable to consider how far it is what it "professes to be, a system of philosophy of the human mind, founded on the physiology of the brain." (Combe, 'System of Phrenology,' p. 1.) Neglecting for the present all metaphysical views on the subject, and regarding the theory of the existence of some such primary faculties of the mind as are assumed in phrenology, and of the dependence of each upon a separate portion of the brain, as one deserving of being tested by observation, we will examine only how far the doctrine, as it now stands, is supported by facts of anatomy and physiology, and whether it is capable of being established by the evidence of craniological investigation.

Many of the objections commonly made against phrenology are undoubtedly of little weight: such for example are the statements that in consequence of the irregularities of thickness in the coverings of the brain, it is impossible to determine its form by examination of the exterior. This objection only shows that there are sources of fallacy in the practice of craniology, a fact which no phrenologist denies. But on the greater part of the head, the differences of thickness of the coverings of the brain are not such as would lead into error; the majority of them are nearly constant in their amount, and are easily recognised by any one acquainted with the anatomy of the skull, and the rest are not sufficient to give that degree of elevation or depression to any part of the exterior of the head which would be regarded as indicative of excessive or deficient development of any organ. No one accustomed to post mortem examination can hesitate to admit that the form of the greater part of the exterior of the head corresponds as nearly with that of the surface of the brain as is necessary for craniological purposes. The parts in which the correspondence is often inexact are those over and in the neighbourhood of the eyebrows. The thickness of the superciliary ridge of the frontal bone is variable, and would certainly in some cases make a moderately developed organ appear large; and still more the size of the frontal sinuses (the cavities between the two plates of the frontal bone immediately above and by the sides of the root of the nose) must always be a source of fallacy in determining the size of that part of the adult brain in which the organs of form, individuality, size, and weight, and part of that of locality are supposed to be placed. The estimate of the supposed organ of language also, which is indicated by the prominence of the eye, must be liable to error from the varying quantity of the contents of the orbit. From these several circumstances however the utmost objection that can be raised is, that there must in general be some difficulty in determining the size of these few parts of the brain. In consequence of disease also the whole or parts of the brain may diminish in size without being accompanied by any corresponding change in the external form of the skull.[*] But as a general rule the subjects of disease are excluded in phrenological observations. The objection that parts of the brain have been destroyed without affecting any of the faculties of the mind is also of little weight, unless it be first proved that the organs are not double. The cases of this kind recorded before the promulgation of phrenology cannot fairly be deduced as evidence, because the statements which they contain relative to the preservation of the mental faculties after injuries of the brain, regard only the general powers of sensation, volition, memory, imagination, &c., and not the primary faculties of phrenologists, some of which might have been deficient without their loss being observed. The observations that have been made since, it must be confessed, are not of more weight against phrenology, than those of the loss of peculiar faculties (especially those of language and amativeness) by injury and disease of the brain are in its favour. Experimental mutilations of the brains of animals must be regarded as affording still less conclusive evidence; when a part of the brain is thus removed, the condition of the whole of the rest of its mass is altered by the removal of the pressure of the skull, exposure to the influence of the atmosphere, interference with the circulation of its blood, &c. It is impossible that a correct conclusion upon any part of the functions of the brain should be drawn from experiments of this kind; and the whole of the arguments deduced from them by Rudolphi, Magendie, and others, may therefore be neglected.

Fully admitting the insufficiency of these, as of some other minor objections to phrenology, we come to the consideration of some which must be regarded as more important. If phrenology were true, it might be expected that its applications would extend through the whole animal kingdom, and that according to the degree in which each mental faculty is developed in each animal, we should find a corresponding portion of its brain large or small when compared with that of man. Yet this is so far from being the case, that phrenologists are compelled to rest their opinions almost exclusively on evidence derived from the comparison of the brains of different individuals of the same species, and to suppose that though many faculties are the same in man and the lower animals, yet in each species they are manifested in some peculiar form and structure not admitting of comparison with those of man. This is evidently contrary to the analogical mode of reasoning which we pursue in other instances; all eyes, all ears, and all organs of smell are formed on the same principles, and so we might presume are all organs of the mind; so that as by the size or extent of distribution of their nerves we can determine in each animal the power of its sense of smell or sight or hearing, so by the size of a special part of the brain we might in each estimate the energy of some corresponding faculty. Between the vertebrate and the invertebrate animals, for example, there is an abrupt step in the condition of the nervous system; the brain and spinal cord of the lowest of the former class differ widely from the supra-œsophageal ganglion and the gangliated cords of the latter; we might therefore expect to find an equally sudden deterioration of mental power. Yet none such occurs: but although the supra-œsophageal ganglion (which may be regarded as the brain of insects) is only so much larger than the rest of their ganglia as is proportionate to the number of organs requiring to be supplied with nerves from it, yet none will deny that many insects exhibit more exalted psychical powers than the majority of either fish or reptiles do. But, taking the vertebrata alone, in all of which there is a certain general plan observed in the nervous system, it is not found that in each order or species, when compared with the rest, the parts of the brain are developed in proportion to the energy of the faculty ascribed to each of them. The phrenological function of the cerebellum, for example, is almost equally powerful in all species; yet the absolute and proportionate size of the cerebellum regularly lessens as one descends through the order of vertebrata, and in the batrachia, in which its supposed function is extremely energetic, it is a mere narrow cord passing across the fourth ventricle. The part of the brain too, which is found decreasing as it is examined in the descending scale of vertebrate animals, is not the anterior, the seat of the intellectual faculties, but the posterior, in which are placed the organs of the animal propensities. A fair mode of comparison to determine this is to be found in the degree in which the hinder part of the cerebrum overlaps the cerebellum; in man alone does the former ever completely cover the latter; in idiots it often fails to do so; in monkeys it covers a still less portion; and continuing to descend through mammalia, the posterior lobes of the cerebrum grow constantly smaller, and the cerebellum is proportionally more, and at last completely, exposed. From these facts it might be assumed that the posterior lobes are the seat of some intellectual faculties; and such an assumption can be avoided only by believing that there is no analogy between the form of the posterior lobes of the cerebrum in man and mammalia. It is not denied that these apparent anomalies may exist, and yet phrenology may be true; but in balancing the probabilities of its truth or falsity, they must not be neglected.

The necessity which is felt of limiting the comparison of cerebral and psychical development to individuals of the same species[*] proves that some other condition than size is essential in determining the energy of each faculty, and that peculiarity of form and position of parts of the brain may give the external appearance of excess or deficiency of size; admissions which must throw doubt on the sufficiency of the only means which phrenology possesses of collecting facts to support its theory. If structure and form render it impossible by the size alone to determine the comparative psychical characters of two individuals of different species, the same conditions may often disturb the results that should proceed from comparisons of size in the organs of two of the same species.

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[*] It is commonly stated in phrenological works that as the brain diminishes in size the internal table of the skull grows inwards, increasing the thickness of the skull. The writer is convinced from numerous observations that the space left in the cavity of the skull by the diminution of the volume of the brain is in a large majority of instances filled up by an accumulation of fluid in the pia mater and in the ventricles [Brain, in Nat. Hist. Div.]; and that the skull rarely undergoes any such change in its thickness as would be phrenologically important. Even when the whole, or, as is more rarely the case, a part of the skull does thus increase in thickness, it does not indicate that there was wasting of the parts of the brain immediately beneath it, but more frequently is consequent on a diminution of parts deeply situated, as the optic thalami and corpora striata. The examination of the skulls of those in whom particular organs are supposed to have wasted, must therefore be too fallacious to admit of any conclusions being drawn from them.

[*] Although, to meet the objections mentioned above, phrenologists insist on the necessity of comparing only individuals of the same species, it is to be observed that they readily make use of illustrations favourable to their opinions obtained by the contrary means, as, for example, in the determination of the organs of combativeness and destructiveness by a comparison of carnivorous and herbivorous animals, and of that of constructiveness by comparing the heads of the hare and the rabbit.

In the limited field of the comparison of different individuals of the same species, phrenology is said by its supporters to be established by numberless facts of the correspondence of strength or weakness of each of the faculties with proportionate extent or deficiency of development of its organ; and they maintain that conclusions thus drawn from facts can be overthrown only by facts that contradict them.* But the numerous sources of fallacy which render the presumed facts for phrenology doubtful, present as great an obstacle to the collection of facts against it; and although its theory, which possesses so much plausibility, cannot be altogether overthrown by anything but well-ascertained facts, yet it is fair for any one to withhold his assent to it till he believes that it is supported by a sufficient number of positive and unerring observations; and the more so when he finds it opposed by some, however few, facts, and incapable of explaining several circumstances that might be expected to be placed under its laws. For these reasons the fallacies to which craniological observation is subject must be admitted as casting doubt upon the testimony of phrenologists, who, granting that they are unwilling to deceive, may yet, like all other observers, be charged with the liability to be themselves deceived. We believe that in this we do not step at all beyond the commonly adopted rules of judging from evidence, according to which it is open to every one to disbelieve statements and conclusions that seem to him improbable, although he may not be in a position to disprove them all by facts.

Judging by these rules, the very perfection to which phrenology is supposed to have nearly attained is strong evidence of its improbability. No one will deny that, in its connection with the body, the human mind must be the most difficult branch of physiology. Yet if phrenology be true, the physiology of the brain is more advanced than that of any other organ in the body; and the improbability is presented that two physiologists accomplished more in about 50 years of study of the most difficult branch of the science of life than the united generations of physiologists of all classes for near 2000 years have effected in the most easy. There is not one function of the living body which can be so perfectly illustrated by the most accomplished physiologists as (if phrenology be true) the functions of the mind can be elucidated by a mediocre adherent to its doctrines; and this too while, to every source of fallacy which it has in common with other departments of physiology, it is subject to still greater which are peculiar to itself.

The improbability that the labour bestowed upon phrenology should have had so extraordinary a result, will appear greater when some of the fallacies are pointed out to which the observations that serve for its basis are subject. Admitting that the size of a part of the brain may be taken as a measure of the power of the faculty of which it is presumed to be the organ, it can be a correct measure of power only when all other conditions are the same. This is admitted by phrenologists, who maintain only that, *cæteris paribus*, size is a measure of power; and it may be admitted that in this proposition they are supported by the analogy of other organs of the body. But in all of them, and therefore probably in the brain, the other conditions are fully as important as size; yet phrenologists in their usual practice refer to quality of the brain only when they find that the indications of quantity are manifestly opposed to their opinions. Moreover the estimate which phrenologists make of the quality of the brain, by observing the external appearance and temperament of the individual, is as fallacious as a measure of the state of the whole mass, and is valueless as a sign of the structural condition of each of its several parts. But any one part of the brain may as well differ from the rest in quality as in quantity; an assumption which the phenomena of local diseases, which are much more common than general diseases of the brain, are sufficient to establish, and which phrenologists themselves admit in their explanation of monomania. There is here therefore a manifest source of fallacy in every phrenological observation; a source of fallacy comparable with, but greater than, most of those which have so long obscured the knowledge of the more simple departments of physiology. No one who has had any opportunity of appreciating the difficulty of analysing observations of which such a varying source of error as is here indicated forms a constant part, can avoid suspecting that phrenologists, when they pretend to have overcome the difficulty, have merely wandered into the facilities of error.

Again, if the condition of quality (in which are included many important circumstances connected with both the temporary and permanent state of the brain, each of which is probably not less important than size) must be regarded as a constant source of inappreciable error in estimating the material condition of the organs, there is scarcely less fallibility in the other element of a phrenological observation, namely, the determination of the mental character of the individual examined. The actions of men are taken as the index to their phrenological state; but (not to mention the cases in which men feign the possession of dispositions and opinions which are not their own) it is evident that in numerous instances, in which there is no intention to deceive, the same actions proceed from different motives, and this phrenologists fully admit, for in many cases in which the size of certain parts of the brain does not agree with the apparent energy of the functions usually allotted to them, they refer the prominent actions of the individual under examination to the excess or defect of some other parts of the brain. But if in one case an apparent disagreement between the state of any faculty and of its presumed organ is thus easily capable of explanation by the condition of other faculties and organs, then in every case the state of all the other faculties must become an inappreciable source of fallacy in endeavouring to estimate the condition of any one.

It is unfair to make use of these supplemental modes of determining characters in cases that are opposed to phrenology, and not to admit their influence in those which seem favourable to it. If the actions of a man are to be taken as the index of his mind—but if at the same time it is allowed that the same actions may result from different propensities, desires, and tastes, it is evident that it will be almost impossible to bring the evidence of facts to bear against phrenology, in which there must then be so many facilities of escape from conviction of error. If, to take an illustration from the writings of Sir G. Mackenzie, a young man in whom locality and inhabitiveness are very moderately developed is yet irresistibly impelled to go to sea, by a mechanical genius, and by attachment to the mechanism of a ship, conjoined with perseverance, courage, love of approbation, and ideality, there can surely be no certainty that any one propensity is proportioned to the condition of a single organ rather than to the combined condition of several others.

When we point out these sources of fallacy in every phrenological observation that has been made, and add to them the doubt which is cast upon it by the total absence of any anatomical peculiarity in the brain correspondent with the presumed separation of its organs, and by the failure of its application in the comparison of the psychical condition of man and animals, sufficient has been done to show that a person exercises a justifiable and even a philosophical degree of caution in withholding his assent from phrenology as it at present stands. He may grant, as the writer does, that its theory is ingenious and probable; that its plan of classifying the faculties of the mind is probably more natural than that of any other psychological system; that the existence of many of the assumed faculties admits of little doubt; that a comparison of the heads of different nations and individuals renders it almost certain that the general divisions of the part of the human cerebrum are correct; that in many cases, on balancing the evidence on each side, the result is on the whole favourable to the belief that the positions of several of the organs in each part of the brain have been nearly determined; but without further and very extended inquiry, and that made with a just appreciation of the difficulties of attaining to facts, when so many of the elements of the observations are inappreciable, and conducted by a disposition to doubt rather than to find confirmation of the doctrine assumed, he will hesitate to accept its theory further than as a direction to his inquiries, and will refuse to admit its applications in any important practice.

PHRYGIAN MODE. [MODE.]

PHTHALAMIC ACID. [NAPHTHALIC GROUP.]

PHTHALAMIDE. [NAPHTHALIC GROUP.]

PHTHALAMILE ($C_{16}H_4(C_{12}H_5)_2NO_4$) *Phenyltalimide.* An unimportant derivative from aniline. [NAPHTHALIC GROUP.]

PHTHALANILIC ACID. [NAPHTHALIC GROUP.]

PHTHALIC ACID. [NAPHTHALIC GROUP.]

PHTHALIDINE ($C_{16}H_9N$). An organic alcaloid, produced by the action of sulphide of ammonium upon nitrophthalene ($C_{16}H_7NO$).

PHTHALINIDE. [NAPHTHALIC GROUP.]

PHTHISIS (a Greek word, *φθίσις*, signifying "corruption," "decay") was formerly used as a generic term to signify a wasting or consumption from any cause, and was afterwards more distinctly specified, according to the organ in which it was supposed to originate: hence we had a *Phthisis hepatica, P. mesenterica, P. pulmonalis,* &c.; but the word is now restricted to the disease produced by tubercles in the lungs, and commonly known by the name of consumption. An acquaintance with this disease, from which neither age nor sex is exempt, and no part of the habitable globe is free, whose ravages extend even to the brute creation, and whose course when once begun can rarely be stayed, whose commencement is frequently so insidious, and whose termination so fatal, must, above all others, be interesting; for if by any precaution its development can be prevented, it is only by a knowledge of those influences which most frequently give rise to it that we can hope to attain our object.

Morbid Anatomy of Phthisis.—The local morbid changes peculiar to phthisis are only the result of previous changes in the general system, an hereditary or acquired predisposition, cognisable by the physical condition of the patient, and by a disordered state of various functions, "and which, though very generally accompanied with a feeble organisation, is not inconsistent with too great development and inordinate action of particular parts, and even with considerable physical power of the system." By far the most important and characteristic morbid change that occurs in phthisis consists in the development of tubercles wherever they may be found; but as it is in the lungs that they first and most frequently manifest themselves, we shall describe them as they are seen in these organs. Tubercles of the lungs first appear in the form of small, gray, semi-transparent granulations, which gradually enlarge and become opaque in their centre: the opacity increases, till the whole mass becomes of a dull yellowish-white colour. After a certain time they soften, empty themselves into the bronchial tubes, and give rise to excavations more or less considerable. In this way, almost the whole of both lungs may be invaded by a succession of tubercles, their healthy structure being absorbed as the tubercles become deposited, or involved in the destructive process consequent upon their softening. Tubercles, unlike inflammation, almost invariably commence at the summit of the lungs, where, as well as being more numerous, they are usually found in a more advanced stage of development than in any other part. The successive eruption of fresh tubercles is an important feature in this disease, as it explains the occasional recovery of patients labouring under consumption. A crop of tubercles may appear in the lungs, go through the various stages above described, and give rise to all the symptoms of confirmed phthisis; yet, provided the conditions which gave rise to them are removed, no fresh eruption may take place, and the patient may recover. The relative frequency of tubercles in other organs differs considerably in the adult and in the infant. In the former, M. Louis, our greatest authority in all matters connected with phthisis, has, with one exception, never observed them in any organ without their existing in the lungs; so that he regards their presence in these last viscera as a necessary condition for their development in other parts. But in the infant this does not appear to hold good; the bronchial glands being more frequently affected than the lungs, in the proportion of 87 to 78. The brain and its membranes are likewise more subject to tuberculous deposits in the child than in the adult. The next most important lesion which is met with in phthisis is ulceration of the intestinal canal. The ulcers may vary in number, form, and size; but they all present specific characters peculiar to this disease, and exist in five-sixths of the cases which terminate fatally. The third peculiarity in reference to phthisis is the change which the liver undergoes, to which the French pathologists have given the name of *foie gras*, or fatty liver. Lastly, ulcerations of the epiglottis, larynx, and trachea occur so frequently, and with such uniformity of type, as justly to lead to the belief that they are a part of the disease. But besides these morbid changes, which are peculiar to this disease, complications of various kinds occur which are common to it and other chronic diseases. By far the most frequent of these are inflammations of the pleuræ; so that it is extremely rare, in making the post mortem examinations of persons who die of phthisis, not to find the lungs adherent, in part or entirely, to the walls of the chest. Inflammation of the substance of the lungs is likewise a frequent complication in the latter stages of phthisis.

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* Dr. Spurzheim and his followers constantly call upon the public to decide upon phrenology by their own observations; proving that they regard it no difficult matter to observe and draw correct conclusions in the most ambiguous questions of physiology. Upon this plan there is certainly no theory so absurd but it will easily gain adherents. One cannot feel assured that persons who are so little sensible of the difficulties of observation are themselves fully competent to observe. The more philosophic Dr. Gall did not fail to admonish his auditors not to attempt practising phrenology.

Symptoms of Phthisis.—These generally commence with a slight cough, which at first excites no attention, but is regarded as a simple cold. The breathing is not seriously affected, nor is the appetite impaired. After a time the cough increases in frequency, and is accompanied by expectoration of a clear frothy saliva; the breathing and pulse become a little hurried after meals and towards evening; and at this time of the day there is frequently experienced a slight degree of chilliness, followed by heat, which continues during the greater part of the night, and is succeeded towards morning by perspiration. The patient likewise becomes somewhat paler, and is languid and easily fatigued. In some instances, the first symptoms are preceded by a more or less copious hæmoptysis. In the second stage of phthisis the cough becomes more frequent, especially during the night; and if violent, it sometimes occasions vomiting. Hoarseness, or loss of voice, is not unusual. The expectoration changes its character; it is less frothy and more opaque; containing small particles of a yellowish-curd-like substance; or the sputa are streaked with dull-yellow lines, and hæmoptysis is pretty frequent, but in general not abundant. The breathing and pulse are more hurried; the fever is greater; and the perspirations more regular and copious. Pains in the thorax, denoting pleuritic inflammation, often occur; and the languor and emaciation still increase. In the last stage of consumption there is nearly always profuse diarrhœa, and the sweats and expectoration are more copious; the latter becomes more uniform in composition; and is separated into roundish distinct masses, with flocculent edges. The emaciation and debility keep pace with the other symptoms, and the feet and ankles swell towards evening; the appetite generally declines in the same proportion, and the patient dies in the extreme degree of marasmus, not unfrequently flattering himself to the last with a speedy recovery. In females, the menstrual discharge almost always ceases when hectic fever is established, and occasionally even before that is the case, which has led to a popular opinion that the disease in such cases arises from the suppression. Such are the ordinary symptoms presented by phthisis in its most usual form, but varieties exist in the order and duration of the morbid phenomena. Thus, tubercles may be developed in the lungs, and remain for a considerable period without exciting either cough or expectoration, or even any important general symptoms. In other cases they give rise to intense general symptoms, as fever, emaciation, anorexia, before they excite cough or expectoration, the latter appearing only a short time previous to death. To these cases the term *latent phthisis* has been applied: and what is remarkable in them is, the absence of appreciable organic alteration in organs whose functional derangement was most violent, while the only viscus really affected seems functionally healthy. The term *acute phthisis* is applied to those cases in which the disease goes through all its stages with unusual rapidity. It occurs most frequently in the young, and in those weakened by some previous disorder. In popular language it is designated "galloping consumption." *Chronic phthisis* is the reverse of the last, and comprehends all those cases in which the progress of the disease is unusually slow and generally intermittent.

Diagnosis of Phthisis.—Auscultation and percussion are the chief means by which we arrive at the diagnosis of phthisis [AUSCULTATION; PERCUSSION]; but there are several collateral circumstances which must be taken into consideration in order to form a correct opinion as to the nature of the disease. It is at the commencement of phthisis that an accurate diagnosis is of most importance, and in which the stethoscopic signs are least evident. We shall be therefore more particular in enumerating the indications at this period, than in accurately describing the acoustic phenomena which are present at a more advanced stage of the disorder. As bronchitis is the disease with which phthisis is most liable to be confounded, we shall place in juxtaposition the principal points in which they differ. In the greater number of cases of phthisis the cough comes on without any evident cause, and many months may elapse without expectoration. This apparent absence of cause and dryness of cough are of themselves very remarkable, and differ from what occurs in simple bronchitis. Thoracic pains, when present in the latter affection, are generally felt in the middle of the sternum; while in phthisis they are situated in the sides of the chest and between the shoulders. Hæmoptysis, from the commencement or during the progress of cough, is frequent in phthisis, and is almost a certain sign of the presence of tubercles; whereas this symptom never occurs in bronchitis. Out of twelve hundred patients affected with various diseases, not including cases of amenorrhœa, or those arising from external violence, M. Louis found that not one, with the exception of phthisical cases, had experienced this symptom. Auscultation gives us little or no aid in the earliest stages of phthisis; and when the stethoscopic signs first manifest themselves, they are such as result from an increased density in the structure of the lung, and not from the presence of fluid in the bronchi, as is the case in bronchitis. Thus the expiration, which in health is scarcely audible, becomes more distinct; the voice more resonant; the sound elicited on percussion duller. These alterations in the respiration, and in the signs produced by percussion, like the development of tubercles, take place from the summit to the base of the chest, and at first are almost constantly confined to the upper lobe of one side. In bronchitis the sounds result from fluid in the bronchi, and originate in the lower part of the chest, and usually on both sides. In the more advanced stage of phthisis its diagnosis is less difficult, and is made from a consideration of the sputa, which we have already described, and from the signs furnished by percussion and auscultation. These are now decisive: the upper parts of the chest are dull on percussion; the respiratory murmur is strong, coarse, or even cavernous under the clavicles; and the voice listened to in the same situation gives rise to that peculiar phenomenon termed pectoriloquy. If there should be much fluid in the lungs, resulting from the patient's not having lately expectorated, we then have a mucous rattle in all those parts of the chest corresponding with the seat of the disease; and where cavities containing fluid exist, the air passing through this produces that gurgling noise to which the term *gargouillement* has been applied by the French. The space in which these different changes take place is at first limited; but it daily increases, and in some instances, where the entire upper lobe of the lung is converted into numerous excavations, the respiration is coarse and more or less tracheal throughout its whole extent. The diagnosis of latent phthisis is not difficult, provided we make use of the proper means for ascertaining the condition of the pulmonary organs; the evil is, that the attention is directed exclusively to those functional derangements which we have spoken of when describing latent phthisis, while the real seat of the disease is overlooked.

Duration and Mortality of Phthisis.—Various circumstances affect the duration of phthisis, as age, sex, constitution, occupation, season of the year, climate, &c. In the upper ranks of life, where patients have all the advantages that a proper regimen, change of air, and good medical treatment can afford, the average duration of the disease is considerably above that in the lower classes.

The mean duration of 314 cases tabulated by MM. Louis and Bayle was 23 months, including the extreme cases; but 162, or more than half of the cases, terminated in nine months, and the greater proportion of them between the fourth and ninth month. By excluding those cases which terminate within four months, and those that exceed four years, the average duration of the remaining cases is 18 months. With regard to the mortality from phthisis, it varies in different climates, ages, sexes, races, and occupations. In England and Wales, according to the Report of the Registrar-General of Births, Deaths, and Marriages,' it is 20 per cent. of the total number of deaths, or 3·82 annually out of 1000 living. In France it is about the same. On the eastern frontiers of the Cape of Good Hope, where the atmospheric vicissitudes are sudden and great, the thermometer in summer sometimes varying from 110° to 64°, and in winter from 75° to 32°, in the course of a few hours, it is only 3½.

In cities the majority of the male labouring population is engaged in the arts, trades, and manufactures, and generally for many hours together in ill-ventilated apartments, and in unhealthy postures of body. In the country the pursuits of the same class of persons are chiefly agricultural. In respect of age, the deaths are greatest between 20 and 30, and diminish gradually to between 50 and 60, after which deaths from phthisis are comparatively unfrequent.

Causes of Phthisis.—The causes of phthisis, says Sir J. Clarke, may be divided into "the remote and the exciting, or those which induce the constitutional predisposition, and those which determine the local deposition of tuberculous matter after such predisposition is established. The one class of causes operates by modifying the whole system; the other, by determining in a system so modified the particular morbid action of which tuberculous matter is the product." Of the remote causes, or those which induce the constitutional predisposition, hereditary transmission is regarded as the most powerful; not that an individual born of consumptive parents will himself necessarily fall a prey to the same disease, but only that, when exposed to those influences which we are about to enumerate as determining the tuberculous cachexia, he will be more likely to become affected than one born of healthy parents.

At the same time it must be remembered, that with a disease so common as phthisis, a certain number of persons would be descended from phthisical parents who might contract the disease independent of hereditary descent. Dr Walshe, after the examination of 446 cases of disease phthisical and non-phthisical, came to the conclusion that "phthisis in the adult hospital population of this country is, to a slight amount only, a disease demonstrably derived from parents," and it would appear that this is generally true of the middle and upper classes of society in Great Britain.

Whatever may be the real amount of tendency to this disease given by hereditary transmission, there can be no doubt that external circumstances produce a powerful effect. Thus it is found that the death rate from phthisis is much higher for towns than it is for country districts, thus pointing to the fact that the circumstances by which persons are surrounded in towns are more favourable to the development of phthisis than in country districts. Although much may be set down to the wear and tear of a town life as compared with the country, yet when we come to examine the class of persons affected in towns, we are driven to the conclusion that one of the most powerful causes of the development of phthisis is a deficient oxygenation of the blood. It is found that in London, the deaths from phthisis amongst persons confined in shops is as 2 to 1 compared with the gentry and professional classes. Taking the trades of London, it is found that those which are sedentary favour the development of phthisis much more than those where the occupation is more active. Again, those who work in close and ill-ventilated rooms are more liable to this disease than those who work in more open and better ventilated apartments. In the case of persons who are exposed to the open air, as found by the recent parliamentary inquiry into the state of the barracks for soldiers in London, and nevertheless suffer from phthisis, it has been discovered that they sleep in close and ill-ventilated apartments. The immunity of some districts in Great Britain, as the Hebrides and north-western districts of Scotland, may be attributed to the almost perfect ventilation of the huts or cabins in which the principal part of the population resides. As an illustration of the influence of overcrowding, and the consequent elimination of the oxygenation of the tissues, the following illustration may be given. In the parish of St. James's, Westminster, there are three registration districts; in one of these 134 persons dwell upon a single acre, in a second 262, and in a third 432 persons live upon an acre. In 1858, the death from phthisis in these districts was as follows: in the first division one person in every 426 died of phthisis; in the second, one in every 422, whilst in the third and most thickly populated district, one in every 327 of the population died. There are however other conditions which lead to the same deficiency of oxygenation in the blood, and which act as occasional predisposing causes of pulmonary consumption. Such are exhausting occupations, inactivity of body, mental depression, insufficient food, and the abuse of spirituous liquors.

The more immediate or exciting causes of consumption, those which determine the deposition of tubercles, have usually been attributed to irritants acting locally on the bronchial tubes or on the lungs, whether occasioned by inflammation of these parts or by the mechanical action of irritating bodies upon them. The result of the latest investigations on this subject leave no doubt that the influence exerted in this way has been greatly exaggerated. Pneumonia and bronchitis, the two diseases hitherto regarded as the most frequent forerunners and producers of phthisis, have been shown by M. Louis to exert no more influence in its production than any other disease. They may indeed occasionally hasten the development of tubercles, but they exert no specific effect, and they act only as remote causes in impairing the health generally. These conclusions of Louis, which have been deduced from his own observations in hospital practice solely, receive ample confirmation from the admirable Statistical Reports of the Registrar-General and Major Tulloch, which we have before referred to. The popular error of attributing consumption to cold, the breaking of a blood-vessel, &c., has probably originated from mistaking the effect for the cause. We have shown in a former part of this article that cough and hæmoptysis are among the earliest symptoms of tuberculous lungs.

With regard to mechanical irritants, as dust of various kinds, noxious gases, smoke, &c., "no opinion has been more prevalent," observes Dr. Cowan, "than that those who are exposed to the inhalation of the dust of vegetable, mineral, or animal substances, are peculiarly liable to phthisis; and in the supposition that consumption was essentially a disease of the lungs, and in the great majority of instances the result of bronchial inflammation, no conclusion was more natural or more probable. But once remove from the mind the impression of a necessary connection between bronchitis and tubercles, and we feel persuaded that the examination of the evidence brought forward on the subject of dust will terminate in the conviction that this agent exerts at most but a very secondary and unimportant influence in the production of phthisis." The mortality among the workmen in some of our manufacturing towns is usually brought forward in support of the doctrine of mechanical irritation. Dr. Knight, of Sheffield, informs us that there is not an example of a polisher of forks reaching his 36th year, nor do the artisans in other departments attain a much greater age. But it must be recollected that many of these men work sixteen hours a day in a close atmosphere and confined posture of body, two conditions which contribute perhaps more than any other to the increase and production of phthisis. Nor has the mortality been diminished by the use of magnets, wire masks, currents of air, and moisture, which have been successively tried for the purpose of arresting the metallic particles. In the cases of 887 quarrymen, 557 stone-cutters, and 160 marble-workers, all of them occupations involving the inhalation of dust, M. Benoiston found the proportion of phthisis was less than the general average; but then these are employments carried on in the open air. Dr. Lombard, whose researches are founded on a total of 4300 deaths from phthisis, and 54,572 individuals, exercising 220 different occupations, found, by a comparison of all the professions carried on in the open air and in workshops, that the proportion of deaths from phthisis was *double* among the latter; and this proportion increased as the apartments were close, narrow, and imperfectly ventilated.

Mr. Watson, a surgeon of Wenlockhead, a mining district, informs us that, out of 74 men working during four or five months for sixteen hours daily in a mine where a candle burnt with difficulty, not one was attacked with any pulmonary affection. But whether from the inhalation of any noxious gases or from other causes, it is certain that in the majority of the mining districts of this country the mortality from phthisis is high. The number of males attacked by this disease in Cornwall exceeds that of the females in the ratio of 170 to 140, and in the mining parts of Staffordshire, Shropshire, and Worcester, in the ratio of 203 to 191; while in the non-mining districts of Staffordshire and Shropshire, and in the county of Cheshire, the ratio is 656 males to 796 females.

The influence of smoke, when uncombined with other agents of injurious tendency, may, we think, fairly be called in question. In Leeds, which is certainly the most smoky place in the whole kingdom, the mortality of females from phthisis is below that of most of our large manufacturing towns, and is not much above the average for the whole of England and Wales. In London likewise this is the case, and in nearly the same proportion.

A moist and changeable climate was long regarded as among the most active causes of consumption; and Great Britain, whose climate combines these two conditions in a remarkable degree, has been looked upon as such a nursery for phthisis, that our facetious neighbours on the other side of the Channel have styled it "La Maladie Anglaise." Indeed the notions of atmospheric vicissitudes, dampness, and consumption, seem almost inseparable. However, these opinions have been and still are undergoing a severe scrutiny; and the evidence which we at present possess on the subject tends very strongly to disprove their correctness. Moisture and climate, like all other agents, act either locally or generally; popular belief has attributed their presumed prejudicial effects to local action. They tend, it is said, to produce catarrhs and coughs, and consequently consumption. We need scarcely allude again to the fallacy of this opinion. We are in possession of little information on the mode in which climate operates to the production of phthisis. That the disease prevails to a much greater extent in some climes and localities than in others, is an indisputable fact; but it is no less certain that its prevalence is not confined to countries of variable temperature, for many of such countries suffer in a much less degree than those whose thermometric range varies little throughout the year. Is phthisis contagious? This is a question which has been often discussed, and numerous are the testimonies both on the affirmative and negative side; but the weight of the evidence seems to rest with the non-contagionists.

Treatment of Phthisis.—This resolves itself into two kinds: first, the *prophylactic*, or that which has for its object the prevention of phthisis in those who are hereditarily or otherwise predisposed to the disease; and secondly, the *curative*, or that which endeavours to arrest its progress after tubercles have manifested themselves. Much may be done in the first case; but experience proves the limited control that we possess over it in the second. Phthisis, as we have said before—and, as we are anxious to impress this fact upon our readers, we again repeat—is not a mere local disease, or one arising from local causes; but it results from a general depravation or unhealthy condition of the whole system, of which tubercles are only an effect. They may be considered as the last of the embryonic changes previous to the nascence of the disease in a cognisable form.

This being premised, our prophylactic treatment must be directed towards the prevention or the arresting of the incipient changes which take place previous to the development of tubercles. With this view the most obvious rules are, to avoid all those causes which we have pointed out as tending to produce the tuberculous diathesis. Marriages should be made with greater regard to the health of the contracting parties. Children, especially if sickly, should be reared and educated with less anxiety about their mental progress than their bodily strength. Those professions and trades should be avoided which combine much sitting, with a confined posture of body, as those of tailors, shoebinders, shoemakers, milliners, lacemakers, engravers, jewellers, watchmakers, clerks, &c., all of whom are peculiarly subject to phthisis. Agriculturists, butchers, carters, coachmen, sailors, &c., are remarkable for their general health and their freedom from this complaint. All occupations therefore that are carried on in the open air should be chosen in preference to those of an opposite kind. Calisthenic exercises, when indulged in with moderation, are healthful, and should by no means be neglected. In short, everything which tends to invigorate the body diminishes disease; and it is proved by statistical facts, that wherever the mortality from disease generally is low, the mortality from phthisis is also low.

It is a matter of the greatest importance to be able to detect the symptoms of an approaching tuberculous attack. · Individuals liable to phthisis frequently present a peculiar organisation. In one group the complexion is fair, the form delicate, the skin thin, and the subcutaneous veins numerous, the pupils of the eyes are unusually opacious, and the eyeballs are large and prominent. Another group of individuals predisposed to phthisis have a dark complexion, disagreeable features, joints large, the skin thick and sallow, eyes dull, upper lip tumid, and the general expression is heavy and listless. The development of phthisis is also preceded by a peculiar form of indigestion, which has been called "strumous dyspepsia." This dyspepsia is accompanied with heartburn, acid eructations after taking food, and is especially attended with a dislike of fatty food, which frequently extends to sugar and alcohol. Such symptoms should have anxious attention, and everything be done to prevent their further development. In this stage attention should be given to exercise, the state of the skin and bowels, and a treatment adopted to rectify the condition of the digestive organs. Recent writers have drawn attention to the physical signs of a "pretubercular stage," which is said to consist in the slightest subclavicular dull percussion sound, with lessened vesicular murmur, less forcible and deep inspiration and flattening of the apex of the lungs. "Such signs could only be discovered by an accomplished stethoscopist; but wherever indications of dullness in either lung is discovered in conjunction with the above dyspeptic symptoms, there is cause for anxiety, and a precautionary treatment should be at once adopted."

The curative treatment of phthisis consists in regulating the health generally, and in combating particular symptoms. For the attainment of the first object, the diet should be nutritious, but not stimulant; and the exercise regular, but gentle, and not too prolonged. Horse-exercise is particularly recommended in the incipient stage of phthisis, and travelling may be safely undertaken in certain circumstances. Of all the modes of travelling, sea-voyages are perhaps the most beneficial; and where much improvement has taken place during the voyage, it would be better to repeat it than hazard the doubtful benefit of a residence on land. The influence of climate on consumption, we are inclined to believe, is imperfectly understood. It has been laid down as a general principle, that the change from a variable temperature to one of an opposite description is in the highest degree advantageous, and, *cœteris paribus*, we think this may safely be admitted; but in recommending patients to climates which possess this uniformity of temperature, it has been too often overlooked that there are other counteracting circumstances which more than neutralise this advantage. Examples abound of the mortality from phthisis in many countries which are remarkable for the equability of their temperature, while others, as the Madras presidency of India, and the eastern frontier of the Cape of Good Hope settlement, to which may be added New South Wales and South Australia, all of them countries subject to sudden and great changes of temperature, enjoy an extraordinary immunity from phthisis. The practice of sending patients to a foreign country who are in the last stage of consumption, cannot be too strongly reprobated. Much difference of opinion exists on the relative advantages attending a residence on the coast or inland for consumptive patients. From the great benefit of sea-air in all scrofulous disorders, and from a review of the causes of phthisis, we are inclined to think that the sea-coast on the whole is preferable. Where circumstances render removal to an anti-phthisical country impossible, confinement to apartments where the heat is regulated, and the purity of the air as much as possible preserved, during the more rigorous weather of this climate, may be recommended. It must however be recollected that this mode of treatment, being unfavourable to improvement of the general health, should only be enforced when exposure to the air is constantly attended with increase of the symptoms. The invention of the respirator has in a great measure obviated this inconvenience; and the phthisical patient, when warmly clad and furnished with this instrument, may be allowed to take exercise in the open air, not only with impunity, but with positive benefit.

With regard to medical treatment many remedies have been recommended, but none have obtained the general reputation and universal acceptation of cod liver oil. The introduction of this remedy has formed an era in the history of the treatment of phthisis, and a larger amount of evidence exists in favour of its beneficial effects than of any other remedy. One of the great indications of treatment in phthisis is to improve the faulty nutrition through which the tuberculous deposits take place, and the agent most adapted for this purpose is the cod liver oil. Under its use persons who have become emaciated speedily gain flesh, and with this result all the symptoms of disease improve. If administered in the early stage of the disease there is evidence to prove that the tuberculous deposit may be arrested, and the patient if not cured at least restored to a state of health in which the disease does not progress. This, however, cannot be predicated of a large number of cases, but it is something in a disease like phthisis to have a prospect of doing this at all. This medicine is used extensively at the Consumption Hospital, Brompton, where 600 gallons of the oil are consumed annually.

Besides cod-liver oil, other fatty substances may be administered in phthisis. Thus, in the diet, fat meat, butter, cream, oily fish, bacon, caviare, and the marrow of the bones of oxen may be recommended.

From the efficacy of bark, sarsaparilla, iron, and iodine, in scrofula and some other diseases attended with constitutional debility, it has been imagined that these medicines must necessarily prove beneficial in phthisis; and there can be no doubt that their tonic properties, when not contra-indicated by the existence of inflammation or much febrile excitement, may safely be put in requisition in the treatment of phthisis. Another class of remedies, of a totally different nature, but not less efficacious when judiciously applied, may be called anti-inflammatory. Such are bleeding, either general or local; mercury, digitalis, counter-irritation. The last is one of the most powerful therapeutic agents that we possess, and, like all other remedies, when used in the commencement of disease presents the greatest chance of success. It is inapplicable when much fever is present, and should never be carried to the extent of producing constitutional disturbance.

These are the general remedies employed in phthisis. The more prominent symptoms of the disease require to be combated by particular medicines which we have yet to name, or by a combination of those just enumerated. One of the most constant and harassing of the symptoms of consumption is cough, which, by interrupting sleep and accelerating the circulation, exerts an injurious influence over the general comfort and health of the patient. It may be tranquillised by the application of sinapisms, tartar emetic ointment, or stimulating plasters to the walls of the chest. In addition to these measures, the cough may be calmed by mucilaginous mixtures, decoctions of Iceland moss, small doses of hyoscyamus, Prussic acid, opium, ether, &c. Perspirations in phthisis are very common, and when profuse tend to weaken the patient. They are checked by exhibiting acids. The sulphuric acid given with quinine, or the nitric acid in a decoction of sarsaparilla, are the most eligible combinations for combating this symptom. We have seen that the diarrhœa which takes place in phthisis is the result of inflammation and ulceration of the intestinal canal: a knowledge of this fact will at once regulate our treatment. All stimulating food and medicine must be avoided; the external surface of the body generally, and the abdomen in particular, should be kept warm; gentle counter-irritation may be made to the latter, and small doses of rhubarb and opium, chalk and opium, or lime-water and milk, may be given internally. With respect to the treatment of pneumonia and pleurisy, which are so frequent in the latter stages of phthisis, we cannot be too cautious. It must never be forgotten that they are mere complications; and in any depletory measures which may be thought necessary, the original disease upon which they are engrafted must not be lost sight of. On the whole, local bleeding by leeches or cupping is preferable to venesection, and counter-irritation to both. For an account of hæmoptysis and its treatment, see HÆMOPTYSIS.

PHYCIC ACID. The *Protococcus vulgaris* contains a nitrogenous acid which is deposited from the alcoholic extract in voluminous acicular crystals which are insoluble in water, but soluble in alcohol, ether, and fixed or essential oils. Its silver salt is white when first prepared, but soon blackens on exposure to light.

PHYCITE. [Mannite.]

PHYLLORETIN ($C_{10}H_8$?). A crystalline resin found native in the peat of Denmark.

PHYSALIN ($C_{28}H_{16}O_{10}$). A bitter amorphous body contained in the *Physalis alkekengi*, and sometimes employed as a remedy in intermittent fevers. It is a light yellow powder, very slightly soluble in cold water, but very soluble in alcohol and chloroform.

PHYSETOLEIC ACID ($C_{32}H_{30}O_4$). An oily acid, obtained from the oil of the sperm whale (*Physeter macrocephalus.*)

PHYSICAL FORCE, CONSERVATION OF. The principle of the "*Conservation of Force*" is thus defined by Helmholz, in a memoir read before the Physical Society of Berlin, on the 23rd of July, 1847, of which Professor Tyndall has given a translation in the 'Scientific Memoirs' for February, 1853:—

"In all cases of the motion of free material points under the influence of their attractive and repulsive forces, whose intensity depends solely upon distance, the loss in tension is always equal to the gain in *vis viva*, and the gain in the former equal to the loss in the latter. Hence *the sum of the existing tensions and vires vivæ, is always constant*. In this most general form we can distinguish our law as *the principle of the conservation of force*."

The importance attributed to this principle by men of science, who are competent judges, will appear from the references to it in the following article.

PHYSICAL FORCES, CORRELATION OF. The *Correlation of Physical Forces* is an important theoretical principle or doctrine in natural philosophy,—taking the latter designation of science in its widest sense,—which has been enunciated within these few years past by Mr. W. R. Grove, the inventor or discoverer of the gas voltaic battery, and of the powerful voltaic combination of four elements called by his name, and sometime professor of experimental philosophy in the London Institution.

The intimate connection of all the forces of nature with each other, and their dependence upon one common principle, had been asserted by many philosophers with more or less precision; and the mutual convertibility of two, or perhaps more, of them had been taught at various prior, though not distant, epochs in the history of natural knowledge. But the *Correlation*, or necessary mutual dependence and convertibility, of every one of the physical forces upon and into any other, or into all, and of all, reciprocally, into each other, at the period of its original enunciation, was a doctrine peculiar to Mr. Grove. It was first publicly announced by him in 'A Lecture on the Progress of Physical Science since the Opening of the London Institution,' delivered in the theatre of that institution on the 19th of January, 1842, and afterwards printed for distribution to the proprietors (or members), but not published, though reports of the lecture had appeared in some of the public journals. In the following year it was fully developed in a course of six experimental lectures, 'On the Correlation of Physical Forces,' a designation of the subject and of the principle then first employed by Mr. Grove; the substance of which was printed three years afterwards (August, 1846), both for the members of the institution and for the public, under the same title. Of this work, the author published a second edition in 1850, and a third, considerably enlarged, in 1855. The Abbe Moigno has produced a translation of it into the French language.

So much, in this place, for the history of the subject. We shall now proceed to give, as nearly in the author's words as possible, his views respecting it, but deviating to some small extent, for the objects of an expository article, from the order in which he has explained them, and occasionally introducing comments of our own. Our quotations are exclusively from the third edition of Mr. Grove's work.

The position which Mr. Grove has sought to establish "is, that the various affections of matter which constitute the main objects of experimental physics,—namely, heat, light, electricity, magnetism, chemical affinity, and motion,—are all correlative, or have a reciprocal dependence; that neither, taken abstractedly, can be said to be the essential cause of the others, but that either may produce, or be convertible into, any of the others: thus heat may mediately or immediately produce electricity, electricity may produce heat, and so of the rest, each merging itself as the force it produces becomes developed; and that the same must hold good of other forces, it being an irresistible inference from observed phenomena that a force cannot originate otherwise than by devolution from some pre-existing force or forces." That any one of these physical forces "may, *mediately* or *immediately*, produce 'the others,' is all," Mr. Grove remarks, "I can venture to predicate of them in the present state of science; but after much consideration, I incline strongly to the opinion that science is rapidly progressing towards the establishment of immediate or direct relations between all these forces. Where at present no immediate relation is established between any of them, electricity generally forms the intervening link or middle term."

"The term correlation," says Mr. Grove, further, "which I selected as the title of my lectures in 1843, strictly interpreted, means a necessary mutual or reciprocal dependence of two ideas, inseparable even in mental conception: thus the idea of height cannot exist without involving the idea of its correlate, depth; the idea of parent cannot exist without involving the idea of offspring. It has been scarcely, if at all, used by writers on physics; but there are a vast variety of physical relations to which, if it does not in its original strictest sense apply, cannot certainly be so well expressed by any other term." [*sic.*]

"The probability is that, if not all, the greater number of physical phenomena are correlative, and that, without a duality of conception, the mind cannot form an idea of them."

Thus, the sense Mr. Grove has attached to the word correlation is "that of a reciprocal production; in other words, that any force capable of producing another may, in its turn, be produced by it—nay, more, can be itself resisted by the force it produces, in proportion to the energy of such production, as action is ever accompanied and resisted by reaction: thus, the action of an electro-magnetic machine is reacted upon by the magneto-electricity developed by its action."

"To many, however, of the cases" of the reciprocal production of physical phenomena, "the term correlation may be applied in a more strict accordance with its original sense: thus, with regard to the forces of electricity and magnetism in a dynamic state, we cannot electrise a substance without magnetising it,—we cannot magnetise it without electrising it: each molecule, the instant it is affected by one of these forces is affected by the other, but, in transverse directions; the forces are inseparable and mutually dependent, correlative, but not identical."

"Matter and Force are correlates, in the strictest sense of the word; the conception of the existence of the one involves the conception of the existence of the other."

In many cases where one physical force "is excited, or exists, all the others are also set in action: thus, when a substance, such as sulphuret of antimony, is electrified, at the instant of electrisation it becomes *magnetic* in directions at right angles to the lines of electric force; at the same time it becomes *heated* to an extent greater or less according to the intensity of the electric force. If this intensity be exalted to a certain point the sulphuret becomes luminous, or *light* is produced: it expands, consequently *motion* is produced: and it is decomposed, therefore *chemical action* is produced." . . . "This simultaneous production of all the known affections of matter," Mr. Grove adds, "seems to me a strong argument in favour of their being modes of motion," in agreement with the conception of their intrinsic nature which he has enunciated.

Motion, the most obvious, the most distinctly conceived of all the affections of matter, will directly produce *heat* and electricity: and electricity, being produced by it, will produce *magnetism*—a force which is always developed by electrical currents at right angles to the direction of those currents. *Light* also is readily produced by motion: either directly, as when accompanying the heat of friction, or mediately, by electricity resulting from motion. In the decompositions and compositions which the terminal wires proceeding from the conductors of an electrical machine develope when immersed in different chemical media, we get the production of *chemical affinity* by electricity, of which motion is the initial source. Lastly, motion may be again reproduced by the forces which have emanated from motion; thus, the divergence of the electrometer, the revolution of the electrical wheel, and the deflection of the magnetic needle, are, when resulting from frictional electricity, palpable movements reproduced by the intermediate modes of force, which have themselves been originated by motion.

If we now take *Heat* as our starting point, we shall find that the other modes of force may be readily produced by it. Motion is so generally, if it be not invariably, the immediate effect of heat, that we may almost, if not entirely, resolve heat into motion, and view it as a mechanically repulsive force, tending to *move* the particles of all bodies, or to separate them from each other. This molecular motion we may readily change into the motion of masses, or motion in its most ordinary and palpable form; for example, in the steam-engine, the piston and all its concomitant masses of matter are moved by the molecular dilatation of the vapour of water. Heat, then, being a force capable of producing *motion*, and motion, as we have also seen, being capable of producing the other modes of force, it necessarily follows that heat is capable, mediately, of producing them. It will immediately produce *electricity* [Thermo-Electricity], as shown in the beautiful experiments of Seebeck. "With regard to chemical *affinity* and *magnetism*, perhaps the only method by which in strictness the force of heat may be said to produce them, is through the medium of electricity; the thermo-electrical current . . . . being capable of deflecting the magnet, of magnetising iron, and exhibiting the other magnetic effects; and also of forming and decomposing chemical compounds." Heat, however, directly affects and modifies both the magnet and chemical compounds.

To say that heat will produce *light*, is to assert a fact apparently familiar to every one; but, in Mr. Grove's opinion, "there may be some reason to doubt whether the expression to produce light is correct in this particular application:" the correlation of heat and light is not so distinct as with the other affections of matter. "Heat and light appear to be rather modifications of the same force than distinct forces mutually dependent." This is a very important discrimination, and one which is undoubtedly well-founded, but it points to the establishment of a principle which is at variance with Mr. Grove's general hypothesis and conclusions, and tends to their limitation. It indicates (when we consider the relations of heat and light, thus taken together to the other physical forces) that they in reality are the initiating forces of nature, and that when they seem to be produced by the other forces, they are, in fact, merely evolved from them. Much evidence might be adduced from natural phenomena, and the results of experimental research, in favour of this view of the subject. But heat and, light appear to have the power of producing the other forces from the moment of their own origination; and the broad induction from the actual state of our knowledge of their radiation is that they originate in union, and—in an absolute sense—are inseparable, both being always present, though in variable proportions to each other; with, at the same time, a certain reciprocity of presence and activity, the one taking the place of the other to the extent, or in the degree, to or in which the other is absent. The recent experimental researches on radiation of M. Foucault, Mr. Balfour Stewart, and Professor Kirchhoff (‘Proc. of Roy. Soc.,’ and ‘Phil. Mag.,’ 1860, &c.), seem to furnish irrefragable evidence on this point; and a remarkable example of the reciprocity here alluded to, in the relation of animal heat and animal light to each other, was pointed out by Mr. Brayley, in a lecture delivered at the London Institution in 1833, the substance of which was communicated to the Natural History section of the British Association in that year, but not printed till 1835, when it appeared in ‘Phil. Mag.,’ third series, vol. vi. pp. 241-247.

Electricity is characterised by the author of the theory of the correlation of physical forces, “as that affection of matter or mode of force which most distinctly and beautifully relates other modes of force, and exhibits, to a great extent in a quantitative form, its own relation with them, and their reciprocal relations with it and with each other.” Commencing with it as an initiating force, we get motion directly produced by it, in various forms; for instance, in the attraction and repulsion of bodies,* and in the deflection of the galvanometer needle. Electricity directly produces *heat*, as shown in the ignited wire, the electric spark, and the voltaic arc. In these phenomena, also, it directly produces *light*, of the greatest known intensity. It directly produces *magnetism*, as originally shown by Oersted in his great discovery [ELECTRO-MAGNETISM]. Lastly, electricity produces *chemical affinity;* and by its agency we are enabled to obtain effects of analysis or synthesis with which ordinary chemistry does not furnish us.

Light is, perhaps, that mode of force the reciprocal relations of which with the others have been the least traced out. Until the discoveries of Niepce, Daguerre, and Talbot [PHOTOGRAPHY], very little could be definitely predicated of the action of light in producing other modes of force. Viewing the phenomena of photography as resulting from a function of light, we get the latter as an initiating force, capable of producing, mediately or immediately, the other modes of force. Thus, it immediately produces chemical action; and having this, we at once acquire a means of producing the others. In Mr. Grove's lectures at the London Institution in 1848, already mentioned, he showed the following experiment by which the production of all the other modes of force by light is exhibited. “A prepared daguerreotype plate is enclosed in a box filled with water, having a glass front, with a shutter over it. Between this glass and the plate is a gridiron of silver wire; the plate is connected with one extremity of a galvanometer coil, and the gridiron of wire with one extremity of a Breguet's helix: the other extremities of the galvanometer and helix are connected by a wire, and the needles brought to zero. As soon as a beam of either daylight or the oxyhydrogen light is, by raising the shutter, permitted to impinge upon the plate, the needles are deflected. Thus, light being the initiating force, we get *chemical action* on the plate, *electricity* circulating through the wires, *magnetism* in the coil, *heat* in the helix, and *motion* in the needles.”

Light would seem directly to produce heat in the phenomena of what is termed absorption of light. Whenever light is absorbed heat takes its place, affording us apparently an instance of the conversion of light into heat; and of the fact, that the force of light is not, in reality absorbed or annihilated, but merely changed in character, becoming in this instance converted into heat by impinging on solid matter, as heat is converted into light when solid incombustible matter becomes intensely luminous by being introduced into highly-heated but only slightly luminous gas. The difference between the correlation of light and heat and that of the other forces with each other, and with them, has already been noticed, and will also be returned to in the sequel.

Magnetism, as was proved by the important discovery of Faraday [MAGNETO-ELECTRICITY], will produce *electricity*, but with this peculiarity, that in itself it is static; and, therefore, to produce a dynamic force, motion must be superadded to it; it is in fact directive, not motive, altering the direction of other forces, but not in strictness initiating them. Magnets being moved in the direction of lines joining their poles, produce electrical currents in such neighbouring bodies as are conductors of electricity, in directions transverse to the line of motion. So if the magnet be stationary, conducting bodies moved across any of the lines of magnetic force have currents of electricity developed in them. Magnetism can, then, through the medium of electricity, produce *heat, light, chemical affinity*, and *motion*. It can itself be produced by those forces, but cannot produce them except when in motion, which, therefore, is to be regarded in this case as the initiative force. Magnetism will, however, directly affect the other forces, light, heat, and chemical affinity, and change their direction or mode of action, or, at all events, will so affect matter subjected to these forces that their direction is changed. When this force, however, is in what may be called its dynamic condition, that is, its state of change at the commencement and the termination, or during the increment or decrement of its development, it will produce directly some of the other forces, electricity and heat for example. “But it may be said,” observes Mr. Grove on this point,—and the observation is important with reference to the philosophy of the entire subject of the correlation of physical forces,—“while magnetism is thus progressive some other force is acting on it, and therefore it does not initiate.” This he admits to be true, but urges that “the same may be said of all the other forces; they have no commencement that we can trace. We must ever refer them back to some antecedent force equal in amount to that produced, and therefore the word initiation cannot in strictness apply, but must only be taken as signifying the force selected as the first.” The peculiarity, however, of the mutual relations of heat and light, already noticed, as recognised by Mr. Grove himself, points, as remarked above, to a limitation of the truth of his views in this respect.

Chemical affinity, or the force by which dissimilar bodies tend to unite and form compounds differing generally in character from their constituents, will directly produce *motion* of definite masses, by the resultant of the molecular changes it induces, of which the projectile effects of gunpowder are familiar instances. By chemical affinity, again, we can directly produce *electricity*, and through its medium it may be quantitatively converted into the other modes of force: but *heat* and *light* are immediate products of chemical affinity, and chemical action produces *magnetism* whenever it is thrown into a definite direction, as in the phenomenon of electrolysis, a simple instance of which Mr. Grove adduces as presented by his gas voltaic battery. This completes the review of the phenomena arising from the correlation of the physical forces, each taken in turn as the initiating one.

Mr. Grove states his belief that the same principles and mode of reasoning as have been adopted in his Essay, might be applied to the organic as well as the inorganic world; and that muscular force, animal and vegetable heat, &c., might, and at some time will, be shown to have similar definite correlations; but that he has purposely avoided this subject, as pertaining to a department of science to which he has not devoted his attention. He alludes, however, to the experiments of Professor Matteuci, by which it appears that whatever mode of force it be which is propagated along the nervous filaments, that mode of force is definitely affected by currents of electricity; and he states, also, that by an application of the doctrine of the correlation of forces, Dr. Carpenter has shown how a difficulty arising from the ordinary notions of the development of an organised being from its germ-cell may be lessened.

In the ‘Philosophical Transactions’ for 1850, pp. 727-757, is a valuable paper by Dr. Carpenter ‘On the Mutual Relations of the Vital and Physical Forces,’ in which the principle of the correlation of the latter is successfully extended in some detail to the former, the subject of the germ-cell considered, as just alluded to, and, the view of the correlation of the nervous and electrical forces, in particular, which had been proposed by Dr. Carpenter some years before, and had been afterwards formally adopted by Professor Matteuci, fully established. In this paper, perhaps the most important general enunciation on the subject of correlation which has followed Mr. Grove's ‘Essay,’ and certainly the first, of an adequately definite and comprehensive nature, on the application of the doctrine to the phenomena of organisation, the author states, that he “is not aware that any other attempt has been made to *formularise* the entire series of these mutual relations, [the ‘very intimate mutual relations’ of the physical forces] than that which has been put forth by Professor Grove in his short treatise ‘On the Correlation,’ &c.” But Mr. Grove, we must here remark, did much more than merely formularise these relations. He announced a new conception of their nature, which logically speaking, is a *universal* of physics, and this it is which gives his enunciation its true value, and elevates it almost to the rank of a discovery. Another of Dr. Carpenter's introductory remarks concerns “a point on which,” he says, “Professor Grove has not thought it requisite strongly to dwell; namely, the necessity for a certain *material substratum* as the medium” of the conversion of force. The existence, however, of that substratum is a necessary implication of Mr. Grove's entire doctrine. As he considers all the physical forces to be intrinsically affections of matter,—understanding that term (to use the language of philosophical criticism) in its vulgar sense,—the necessity in question is an inseparable element of his theory, and is therefore virtually dwelt upon throughout his Essay.

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* It follows as a consequence of the doctrine of the correlation of forces, that when electricity performs any mechanical work which does not return to the machine, electrical power is lost, having been converted into mechanical force. In a discourse ‘On Inferences from the Negation of Perpetual Motion,’ delivered June 25, 1856, Mr. Grove performed an experiment in which this loss was rendered evident. The acknowledged truth of the impossibility of perpetual motion is applied, deductively, in this discourse, to verify the doctrine of correlation. (‘Proc. of the Royal Institution,’ pp. 152–159.)

Dr. Carpenter has lately (Feb. 24, 1860) returned to this subject, in a discourse delivered at the Royal Institution, and printed in the 'Proceedings' at the meetings of the members, vol. iii., pp. 206-209, 'On the Relation of the Vital to the Physical Forces.' He argues, that when we carefully look into the question, we find that what the *germ* really supplies is not the *force* but the *directive* agency. This agency may be regarded, he observes, like magnetism, as a *static* force; and just as magnetism requires to be (as we have already seen from Mr. Grove) combined with motion to enable it to develope electricity, so does the directive agency of the germ need the co-operation of a *dynamic* force for the manifestation of its organising power. That dynamic force is heat, the influence of which upon the rate of growth and development, both animal and vegetable, is so marked as to have universally attracted the attention of physiologists, who, however, have only recognised in it a *vital stimulus*, calling forth the latent power of the germ, instead of looking upon it as itself furnishing the power that does the work. It is indeed only when the physiological survey is extended from the vital phenomena of warm-blooded animals to those of cold-blooded animals and of plants, that the immediate and direct relation between heat and vital energy, as manifested in the rate of growth and development, or of other changes peculiar to the living body, is unmistakeably manifested. "Hence," Dr. Carpenter concludes, after summarily reviewing the phenomena of vegetable life under this point of view, "we seem justified in affirming that the correlation between heat and the vital force of plants is not less intimate than that which exists between heat and motion. The special attribute of the vegetable germ is its power of effecting the metamorphosis, and of utilising the organising force according to the plan of construction characteristic of each species."

For the details of Mr. Grove's own illustrations and applications of his doctrine, we must refer to his work itself, in which, also, are given his views of the intrinsic nature of the physical forces; views which are inseparable, in his opinion, from the dogma of their correlation. In this, however, we cannot agree with him. That dogma, we conceive, will remain a concrete expression of the truth, as a *first approximation* of great generality, and in point of time *the* first approximation to a general theory, whatever notion may be finally established of the nature of the forces concerned, and whether heat, for instance, be regarded as a motion of the particles of ordinary matter—that is of the matter exhibiting its phenomena—or as a motion of a calorific ether pervading that matter. This discrimination we believe will be found important in the further application and investigation of the subject. In the article GROVE, WILLIAM ROBERT, in the BIOGRAPHICAL DIVISION of this work, some remarks relevant on this head, have been offered with respect to the history and interpretation of the principle of the Correlation of Physical Forces, to which we may now refer as completing, together with the present and following remarks, our view of the subject.

Dr. Faraday's brilliant series of discoveries respecting the forces of nature, and their relations to each other and to matter,—of which Volta's discovery of the pile, Davy's application of it to electrolysis, Oersted's discovery of electro-magnetism, Seebeck's of thermo-electricity, Tyndall's of the relation to structural density of para- and dia-magnetism, and Mr. Grove's own discovery of the gas-battery, may be cited as parallels of single terms in that series,—have probably contributed more than those of any other experimental philosopher to prepare the scientific public mind for the idea of correlation; and they have had this effect, not only on account of their aggregate magnitude, as constituting so great a part of the advance in physics made during the last sixty years, but because, from their bearing so extensively on what Dr. Faraday calls "the dual forms of power," electricity and magnetism, they have exhibited both the actuality of physical correlation, and the convertibility of force, in a manner so palpably intelligible. In the relations subsisting between positive and negative electricity, and north and south magnetism, respectively, we have the mental idea of correlation realised to sensible perception. The relation of those forces themselves is probably a not less perfect correlation, though perhaps of a different order; while their mutual convertibility, in which electro-magnetism and magneto-electricity originate, is so readily demonstrated by experiment.

In an addition (June, 1858) to his discourse on the "Conservation of Force," (a designation introduced we believe by Helmholz, in advocating a principle long tacitly admitted in particular cases, but which had not before been explicitly recognised in its true generality,) delivered in the preceding year (Exp. Res. in Chem. and Phys. p. 461-462), Dr. Faraday says—"Those who admit the possibility of the common origin of all physical force, and also acknowledge the principle of conservation, apply that principle to the sum total of the force. Though the amount of mechanical force (using habitual language for convenience sake) may remain unchanged and definite in its character for a long time, yet when, as in the collision of two equal inelastic bodies, it appears to be lost, they find it in the form of heat, and whether they admit that heat to be a continued mechanical action (as is most probable), or assume some other idea, as that of electricity, or action of a heat-fluid, still they hold to the principle of conservation by admitting that the sum of force, that is, of the 'cause of action,' is the same, whatever character the effects assume. With them the convertibility of heat, electricity, magnetism, chemical action, and motion, is a familiar thought." This is forcibly put, and is perfectly true; but the mutual convertibility of the forces enumerated has only become "a familiar thought" since Mr. Grove's announcement of the principle of their correlation. No one, however, could have more perfectly realised the conception of that principle, or appreciated its importance, than Dr. Faraday, as indeed the preceding extract may itself show. The latest course of lectures delivered by him (and published in the 'Chemical News') consisted of 'Illustrations of the Various Forces of Matter,—*i. e.*, of such as are called the Physical or Inorganic Forces, including an Account of their Relations to each other.' The subject of the concluding lecture, given on the 7th of January last (1860), was, *eo nomine*, 'The Correlation of the Physical Forces,' of which many experimental demonstrations were shown, relating chiefly to the change of chemical force into electricity, and of electricity into magnetism; and this eminent explorator of physical truth, observing to his audience that he might show them many other experiments by which he could obtain electricity and chemical action, heat and light from a magnet, terminated his course by the emphatic question, "But what more need I show you to prove the universal correlation of the physical forces of matter, and their mutual conversion one into another?"

A certain amount of anticipation of Mr. Grove's views has been recently claimed by Professor Tyndall ('Glaciers of the Alps,' p. 300) for the late M. Rendu, bishop of Annecy, the author of a remarkable essay on glaciers, published in 1841. In considering what he calls the "law of circulation," and after alluding to the circulation of water through terrestrial nature, and that of the elements of organic substances from the solid to the fluid, and thence again to the state of organisation, M. Rendu adds, "That universal agent which we designate by the names fire, light, electricity and magnetism, has probably also a *circulation* as wide as the universe." But this is exactly one of those comparatively vague notions, however true in their degree, referring the forces of nature to a common principle, which have been alluded to in the introductory part of this article, and to which every period in the history of philosophy, for at least a century before, supplies a parallel. When Professor Tyndall in sequence claims also for Rendu, on the same account, a degree of anticipation of Helmholz's more recent doctrine of the 'Conservation of Force,' quoting the latter as saying in reference to the "circuit" formed by "heat, light, electricity, magnetism, and chemical affinity," "starting from each of these different manifestations of natural forces, we can set every other in action," he ascribes to Helmholz what had before been explicitly enunciated by Grove, almost in the same words, as may be seen in the preceding statement of his doctrine.

Dr. (late Professor) James D. Forbes ('Reply to Tyndall on Rendu') has already noticed the futility of these claims; but what he, by the free application of *meiosis*, calls "the theoretical inferences of Messrs. Grove and Helmholz," Faraday, as we have seen, accepts as demonstrated principles of nature, and Professor Le Conte, we shall presently find, regards as forming "a necessary truth," and "one of the grandest generalisations in modern science."

Two remarkable circumstances have characterised the history of the reception of Mr. Grove's doctrine of correlation. Many physicists and others who admit in a general manner the principle, seem very unwilling to use the term; while others who explicitly adopt and advocate both, seem equally unwilling to ascribe them to their author, and omit all reference to him.

Thus, in Professor Liebig's 'Familar Letters on Chemistry' (1858), in the preface to the fourth edition, the introduction of a letter (the 13th) 'On the Correlation of the Forces of Inorganic Nature,' is announced in the preface, but neither in that nor in the letter itself is Mr. Grove mentioned, nor indeed are his views given, though his designation of the subject is thus unreservedly employed. It is applied, in the letter, chiefly to a view of natural forces taken by Dr. Mayer of Heilbronn, asserting both their indestructibility and their convertibility, as consequences of the axiom *Causa æquat effectum*, but not dated, and apparently subsequent to the views both of Helmholz and of Grove.

The following introductory paragraph of an excellent paper by Professor Le Conte, of South Carolina College, Columbia, U. S., 'On the Correlation of Physical, Chemical, and Vital Force, and the Conservation of Force in Vital Phenomena,' contains one of the most emphatic and adequate recognitions of the importance of those principles and intelligible terse statements of their nature which has yet appeared; though, even in this, no allusion is made either to Mr. Grove or to M. Helmholz, and the uninformed reader might be led to suppose that being necessary truths they had always been self-evident. "Matter constantly changes its form, but is itself indestructible, except by the same power which called it into being. The same quantity of matter exists in the universe at all times. So also force changes its form constantly, but is itself indestructible, incapable of increase or diminution, and the same absolute amount of force exists in the universe at all times and for ever. The mutual convertibility of the various forms of force is called 'correlation of forces.' The invariability of the absolute amount in the midst of constant change is called 'conservation of force.' This principle of correlation and conservation of force must be looked upon as one of the grandest generalisations in modern science,—a principle startling at first, but when clearly understood and firmly grasped, almost axiomatic. It must be considered a necessary truth, and, as such, is a legitimate basis of deductive reasoning. The correlation of physical forces is universally recognised as a principle in science, and not only so, but has already been productive of many beautiful and useful results." For Professor Le Conte's application of the principle to the history of organic nature, we must refer to the paper itself. 'Amer. Journ. of Science,' Nov. 1859, reprinted in 'Phil. Mag. Fourth Series,' vol. xix., p. 133.

Again, in the introductory address delivered on the opening of St. Thomas's Hospital Medical College, Southwark, London, on the 1st of the present month (October, 1860) by Mr. R. D. Grainger, F.R.S., which has the emphasis of being also a valedictory address on his retirement from the chair of physiology in that school, we find the following passages, which are here cited, not merely for the purpose of claiming for Mr. Grove what of right belongs to him, but because we have in them the sentiments of an eminent physiologist on the correlation of the vital and physical forces. "In the case of the forces implicated respectively in inorganic and organised bodies, it may in the present state of knowledge be very difficult to demonstrate their ultimate identity. Nor need this be a matter of surprise when we recollect how very recently the intimate relations of the several physical forces themselves have been discovered by such researches as those of Oersted, Faraday, and Graham. Chemical force, electricity, magnetism, caloric, and light, act and react on each other in the mode signified by the term correlation, and are probably, as many profound philosophers suppose, only different manifestations of one universal all-prevading force." Proceeding next to the organic forces, the experiments of Matteuci on the nervous and muscular forces are noticed, together with Dr. Todd's proof that the latter is not itself electricity, the evidence of which is stated to be afforded by "phenomena the very counterpart of what Professor Müller pointed out years ago, in regard to the nervous and electric forces." "Now, although," Mr. Grainger continues, "this may seem to indicate an ultimate and essential difference between the electric and muscular currents, it presents the very same condition of things as that expressed by the term 'correlation of forces.'" Farther on he alludes to the maxim, that there is no creation of force, observing that "no force is ever manifested without an equivalent change of matter, which change, according to the wide generalisation of one of our former colleagues, my friend, Dr. Leeson, is in every form—light, electricity, magnetism, gravitation, &c.—ultimately resolvable into motion." 'Lancet,' 1860, vol. ii. p. 352, 353.

Whether Dr. Leeson's generalisation was enunciated prior to Mr. Grove's we are not aware; but it is simply one elementary correlation of the latter. The reader will have observed that while the doctrine, as well as the designation, of the correlation of forces is fully adopted, Mr. Grove's name is not mentioned; nor does it occur anywhere in Mr. Grainger's address.

We have endeavoured in this article to do justice to Mr. Grove, and to the subject to which he has devoted so much attention and thought. The progress of science, in its approach to the abstract truth, consists partly in the ascent to higher and higher generalisations successively, and partly in the limitation of generalisations previously attained, or, in other words, the verification of hypotheses. Fully believing the doctrine of the correlation of physical forces, we stated several years since our opinion that that doctrine is the expression of the deeper or higher truth, that they are all, not excluding mechanical force, effects, or affections, of the ether,—the ether of Hooke, Young, and Fresnel, and generally of the mathematicians and physicists who have advocated the undulatory theory of light and of heat. In the 'Philosophical Magazine' for January, 1859, Professor Challis of Cambridge, thus introduces his theory of the principle:—"It appears to be established by modern experimental researches, that the different physical forces are mutually related by some common condition, or bond of connexion; but what the precise nature of the connexion is, perhaps experiment alone is incapable of determining. This generalisation will become matter of exact knowledge only when it is brought within the domain of mathematics. The great desideratum of the existing state of natural philosophy is a *mathematical theory of physical forces*. After the explanations that have been given of a great variety of the phenomena of light, which is one of those forces, by the hypothesis of a highly elastic medium pervading space, it is not a little surprising that an explanation of the '*correlation*' of the several forces should not have been sought for in the existence of this medium, which would seem to be a vast reservoir of force sufficient to account for all observed dynamical effects." Professor Challis has pursued this subject in a series of elaborate analytical investigations, also published in the 'Philosophical Magazine' for 1859 and 1860. "The principal hypothesis of the theory is, that the physical forces are all consequences of the motions and pressures of a uniform and highly elastic medium pervading space. The variations of the pressures of the medium are supposed to be proportional to variations of its density; and this supposition forms the basis of a mathematical investigation of the relations between the motions and the pressures. Further, it is assumed that the medium acts immediately by pressure on the ultimate atoms of bodies, which are all supposed to be spheres of invariable magnitudes and of the same intrinsic inertia. According to these hypotheses, the different phenomena and properties of bodies depend only on the *magnitudes* of their atoms, the *proportions* in which they are composed of atoms of *different* magnitudes, and on the *arrangements* of the atoms." As the explanation of the sensible properties of matter must be preceded by a mathematical investigation of the laws of the dynamic action of the assumed etherial medium, Professor Challis has already entered on such an investigation relatively to light, heat, the force of gravity, the forces of molecular aggregation, and the force of electricity; and is still proceeding with the explanation of his theory.

We will conclude this article by the suggestion that progress in natural philosophy, in both the directions indicated above, would probably be effected by the experimental and mathematical investigation of the following theorem:

Taking *space* to be the extension of material substance, the resultant of its dimensions, and mere consequence of its existence; and *motion* to be the substitution of one portion of matter for another, identical with the succession of phenomena, our perception of which is *time:* heat and light are correlates of each other, being also, as we receive them from the sun, and as existing in their terrestrial form, affections of an ether pervading space and ordinary ponderable matter; but acting as the initiating forces in respect of electricity, magnetism, and chemical affinity, which are correlates of each other of a different order, and derivative affections of the ether (perhaps, also, derivatively from the ether, of the matter exhibiting their phenomena), the apparent production of heat and light by them being in reality the *evolution* only of those initiating forces: all these forces have the power of substituting one portion of matter for another, or of causing motion; the apparent agency of time and motion being merely the continuance and consequent accumulation of action.

PHYSICIAN (*ὁ φυσικός*), a word derived from *φύσις*, *nature*, which meant originally what we should now call a *natural philosopher*, or one of those persons who have for their object the investigation of nature and its laws, in opposition to *οἱ ἠθικοί*, or those who examine particularly into the moral nature of men. [PHILOSOPHY.] In English however the word *physician* is used only to designate the professors of the healing art, called in Greek *ἰατροι*, and in Latin *medici;* while in most (if not all) other European lanaguages the derivatives of the Greek word are still employed in their original meaning, and the idea of *healing* is expressed either by some native word or by one derived from the Latin.* The origin and progress of physic, together with an account of the different medical sects, has been given already under MEDICINE; in the present article it is proposed to mention some of the most curious and interesting facts respecting the rank, education, &c., of the physicians of antiquity, and afterwards to state the legal qualifications for practising this branch of the medical profession in our own country.

In Greece and Asia Minor the profession of medicine seems to have been held in high esteem, for, not to mention the apotheosis of Æsculapius, who was considered as the father of it, there was a law at Athens that no female or *slave* should practise it (Hyginus, 'Fab.,' cap. 274); Ælian mentions one of the laws of Zaleucus among the Epizephyrian Locrians, by which it was ordered that if any one during his illness should drink wine contrary to the orders of his physician, even if he should recover, he should be put to death for his disobedience ('Var. Hist.' lib. ii., cap. 37); and there are extant several medals struck by the people of Smyrna in honour of different persons belonging to the medical profession. (Mead's 'Dissertatio de Nummis quibusdam à Smyrnæis in Medicorum Honorem percussis,' 4to., Lond. 1724.) If the Decree of the Athenians (published among the letters of Hippocrates) be genuine, and if Soranus ('in Vitâ Hippocr.') can be depended on, the same honours were conferred upon that physician as had before been given to Hercules; he was voted a golden crown, publicly initiated into the Eleusinian mysteries, and maintained in the Prytaneum at the state's expense. (See also Pliny, 'Hist. Nat.,' lib. vii., cap. 37.) Some idea of the income of a physician in those times may be formed from the fact mentioned by Herodotus (lib. iii., cap. 131), that the Æginetans (about the year B.C. 532, Ol. 62, 1) paid Democedes from the public treasury one talent per annum for his services, that is (if we reckon, with Hussey, 'Antient Weights and Money, &c.' the Æginetan drachma to be worth 1s. 1¾*d.*), not quite three hundred and forty-four pounds; he afterwards received from the Athenians one hundred minæ, that is (reckoning, with Hussey, the Attic drachma to be worth 9¾*d.*), rather more than four hundred and six pounds; and he was finally attracted to Samos by being offered by Polycrates a salary of two talents, that is (if the Attic standard be meant) four hundred and eighty-seven pounds ten shillings. It should however be added that Valckenaer doubts the accuracy of this statement of Herodotus with respect to the Æginetans and Athenians (and apparently with reason), on the ground that the latter people, at the time of their greatest wealth, only allowed their ambassadors two drachmæ (or 1*s.* 7½*d*) per day, that is, somewhat less than thirty pounds per annum. (Aristoph., 'Acharn.,' v. 66.) It seems to have been not uncommon in those times (as afterwards in the later Roman empire, see ARCHIATER in BIOG. DIV.), for states to maintain physicians, who were paid at the public cost (Xenophon, 'Memor. Socr.,' lib. iv., cap. 2, § 5; Plato, 'Gorg.,' § 23; Strabo, lib. iv., p. 125; Diod. Sic., lib. xii., cap. 13); and these again had attendants, for the most part slaves, who exercised their calling among people of low condition. (Plato, 'De Leg.,' lib. iv., p. 720, ed. Steph.; Boeckh's 'Public Econ. of Athens,' vol. i., p. 160.)

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* Somewhat analogous to this is the use of the Arabic word *hakim* (from *hakama*, 'novit' 'sapiens fuit') which properly means *a wise* or *learned man* in general, but is very frequently used in a restricted sense to signify *a physician*.

In the earlier times of the Roman republic physicians were unknown (Pliny, 'Hist. Nat.,' lib. xxix., cap. 5, ed. Tauchn.); and for some time afterwards the exercise of the profession was in a great measure confined to persons of servile rank; for the richer families having slaves who were skilled in all sorts of trades, &c., generally possessed one or more that understood medicine and surgery. (Middleton's Essay 'De Medicorum apud Romanos degentium Conditione,' Cantab., 1726, 4to., and the various answers to it that appeared on its publication.) To this practice however there were many exceptions; namely, the physician who was taken prisoner with Julius Cæsar by the pirates at the island of Pharmacusa (Sueton., cap. 4), and who is called his friend by Plutarch (see Casaubon's Note on Sueton.); Archagathus, who, being the first foreign surgeon that settled at Rome, had a shop bought for him at the public expense, and was presented with the Jus Quiritium, A.U.C. 535, B.C. 219 (Cassius Hemina ap. Pliny, 'Hist. Nat.,' lib. xxix., cap. 6); Artorius, who is known to have been a physician (Cæl. Aurel. 'De Morb. Acut.,' lib. iii., cap. 14, p. 224), and who is called the friend of Augustus (Plutarch, 'Vita Bruti,' cap. 41, ed. Tauchn., where however it should be noticed that some editions read 'Αντώνιος, instead of 'Αρτώριος); Asclapo, whom Cicero calls his friend ('Epist. ad Divers.,' lib. xiii., ep. 20); Asclepiades, the friend of Crassus the orator (Cic. 'de Orat.,' lib. i., cap. 14); Eudemus, who is called by Tacitus ('Annal.,' lib. iv., cap. 3) the friend and physician of Livia; and others. With respect to the income made by eminent physicians at the beginning of the Roman empire, we learn from Pliny ('Hist. Nat.,' lib. xxix., cap. 5) that Albutius, Arruntius, Calpetanus, Cassius, and Rubrius gained two hundred and fifty thousand sesterces per annum, that is (reckoning with Hussey the mille nummi (*sestertium*) to be worth, before the reign of Augustus, 8*l.* 17*s.* 1*d.*) about two thousand two hundred and thirteen pounds ten shillings; that Quintus Stertinius made it a favour that he was content to receive from the emperor five hundred thousand sesterces per annum (or rather more than four thousand four hundred and twenty-seven pounds), as he might have made six hundred thousand sesterces (or five thousand three hundred and twelve pounds ten shillings) by his private practice; and that he and his brother, who received the same annual income from the emperor Claudius, left between them at their death, notwithstanding large sums that they had spent in beautifying the city of Naples, the sum of thirty millions of sesterces (or two hundred and sixty-five thousand six hundred and twenty-five pounds). Of the previous medical education necessary to qualify a physician for the legal practice of his profession in the early times, we know nothing; afterwards however this was under the superintendence of the Archiatri. [ARCHIATER.]

Among the Arabians the medical profession appears to have been held in high esteem. Many of their chief physicians were Jews or Christians, and some apostatised to Mohammedanism: in some families the profession would seem to have been in a manner hereditary, as in that of Avenzoar (*Ibn Zohir*), five of whom successively belonged to it. (Reiske's 'Abulfedæ Annal. Moslem.,' tom. iv., p. 669.) The qualifications necessary for practising medicine seem to have been rather slight, till the Caliph Moctader, A.H. 319 (A.D. 931), in consequence of an ignorant practitioner's having killed one of his patients, passed a law that no one should be allowed to practise until he had been licensed to do so by the chief physician. (Casiri, 'Biblioth. Arabico-Hisp. Escur.,' tom. i., p. 438.) Some idea of the consideration in which the Arabic and Moorish physicians were held may be gained from the fact that Sancho the Fat, king of Leon, was obliged to go in person to Cordova, A.D. 956 (A.H. 345), to be cured of an illness. ('Mariana,' l. viii. c. 7, tom. i., p. 318; Conde, 'Domin. des Arabes,' &c., t. i., p. 448.)

The first medical school that was established in Europe was that at Salerno (Salernitana Schola) towards the end of the 7th century; the second was probably that at Montpelier, founded about a hundred years afterwards: their course of medical education is unknown, but they doubtless excercised a most beneficial influence on the acquirements, and therefore on the personal rank and consideration of the physicians of the age. For a long time however the profession of medicine was almost entirely confined to the clergy, who indeed were the only persons in those days that possessed any share of learning. Surgery was however given up to the laity, as the clergy were prohibited from undertaking any bloody operation.

Hence arose the distinction of the three regular orders of the medical profession, namely, physicians, surgeons, and apothecaries; and it is to the first of these exclusively that the remainder of this article will be dedicated. The degree of bachelor of physic seems to have been known at Oxford soon after the Conquest; and in the 14th century we find that the degree of doctor of physic was by no means uncommon. (Wood's 'Hist. of Oxford,' vol. ii., p. 765, ed. Gutch; Chaucer's 'Doctor of Physic's Tale.') The English colleges could not of their own authority prevent any from undertaking to practise, though they had not obtained a degree in physic. On this account therefore, in the ninth year of the reign of Henry V., 1422, our universities proposed that an act of parliament should be passed ordering that "No one shall use the mystery of physic unless he hath studied it in some university, and is at least a bachelor in that science. The sheriff shall inquire if any one practises in his county contrary to this regulation; and if any one so practise, he shall forfeit 40*l.* and be imprisoned: and any woman who shall practise physic shall incur the same penalty." (Quoted in Willcock, 'On the Laws of the Medical Profession,' part ii., p. iii.)

This measure had not however the desired effect; indeed there appears to be some doubt whether it ever obtained the force of an act of parliament, on account of its being referred to the privy council for confirmation. In the third year of the reign of Henry VIII., 1511, was passed an act, which is generally received as the first operative law on the subject, and which takes no notice of the supposed statute of Henry V. By this, which is especially aimed against the sorcerers, witches, and smiths, "who can no letters on the book," it is enacted that "no person within the city of London, nor within seven miles of the same shall take upon him to exercise or occupy as a physician, except he be first examined, approved, and admitted by the bishop of London, or by the dean of St. Paul's, for the time being, calling to him or them four doctors of physic; upon the pain of forfeiture, for every month that they do occupy as physicians not admitted nor examined after the tenour of this act, of 5*l.*," &c. &c. After making the same enactment for the different counties, the act goes on to say, "Provided always, that this act nor anything therein contained be prejudicial to the universities of Oxford and Cambridge, or either of them, or to any privileges granted to them." (Willcock, pp. 6, 7; Goodall's 'Hist. of the Col. of Physicians,' p. 1-3.)

In the fourteenth year of the same reign, 1522, another act was passed, by which the examination of physicians was taken from the persons appointed for that purpose by the former statute, and reposed in the college instituted by a charter of that king. [PHYSICIANS, COLLEGE OF.] Under this the university graduates who might desire to practise in London were included, as well as the other physicians; and since that time the legislature has seldom interfered on the subject.

With respect to the present state of the profession, the first class of medical practitioners in rank and legal pre-eminence is that of the physicians. They are (by statute 32 Henry VIII.) allowed to practise physic in all its branches, among which surgery is enumerated. The law therefore permits them both to prescribe and compound their medicines, and to perform operations in surgery as well as to superintend them. These privileges are also reserved to them by the statutes and charters relating to the surgeons and the apothecaries. [SURGEON.] Yet custom has more decidedly distinguished the classes of the profession, and assigned to each its peculiar avocations. The practice of the physician is universally understood, as well by their college as the public, to be properly confined to the prescribing of medicines, which are to be compounded by the apothecaries; and in so far superintending the proceedings of the surgeon as to aid his operations by prescribing what is necessary to the general health of the patient, and for the purpose of counteracting any internal disease. It would be impossible to enumerate here the legal qualifications required by all the different European universities; it will therefore be sufficient to mention these recognised in the British dominions.

In the university of Oxford, for the degree of Bachelor of Medicine, it is necessary that the candidate should have completed twenty-eight terms from the day of matriculation; that he should have gone through the two examinations required for the degree of bachelor of arts; that he should have spent at least three years in the study of his profession; and that he should be examined by the Regius Professor of medicine and two other examiners of the degree of M.D. in the theory and practice of medicine, anatomy, physiology, and pathology; in materia medica, as well as chemistry and botany, so far as they illustrate the science of medicine; and in two at least of the following ancient medical writers, namely, Hippocrates, Celsus, Aretæus, and Galen.

For the degree of Doctor of Medicine, the candidate is required to have completed forty terms from the day of matriculation; and to recite publicly in the schools a dissertation upon some subject, to be approved by the Regius Professor, to whom a copy of it is afterwards to be presented.

At Cambridge a student, before he can proceed to the degree of Bachelor of Medicine, must have entered on his sixth year, have resided nine terms, and have passed the previous examination: the necessary certificates, &c. are much the same as those required at Oxford. A Doctor of Medicine must be of five years' standing from the degree of M.B.

Since the university of London has been chartered, in 1837, the degrees of Bachelor and Doctor of Medicine, among others, have been conferred there. The following are the regulations for these degrees.

For the degree of Bachelor of Medicine.—Candidates to have been engaged for four years in professional study at one or more of the recognised institutions, one year at least to be spent at a recognised institution or school in the United Kingdom. They have also to pass two examinations, at the first of which they must produce certificates of having completed their nineteenth year; of having taken a degree in arts in this university, or in a recognised university, or of having passed the matriculation examination; of having been student for two years at one or more recognised medical institutions, subsequently to having taken a degree in arts; of having attended a course of lectures on descriptive and surgical anatomy, general anatomy and physiology, comparative anatomy, pathological anatomy, chemistry, botany, materia medica and pharmacy, general pathology, general therapeutics, forensic medicine, hygiene, midwifery, surgery, medicine; of having dissected during nine months; of having attended a course of practical chemistry; and of having attended practical pharmacy. Candidates to be examined in anatomy, physiology, chemistry, structural and physiological botany, materia medica, and pharmacy.

To the second examination no candidate can be admitted until two years after passing the first. He must produce certificates of having passed his first examination; of having subsequently attended a course of lectures on each of two out of the four subjects mentioned above; of having subsequently to his first examination dissected for six months; of having conducted at least six labours; of having attended the surgical practice of a recognised hospital or hospitals during twelve months, and lectures on clinical surgery; of having attended the medical practice of a recognised hospital or hospitals during other twelve months, and lectures on clinical medicine; of having subsequently attended to practical medicine in a recognised hospital, infirmary, or dispensary, during six months. The candidate must also produce a certificate of moral character from a teacher in the last school at which he has studied. Candidates to be examined in physiology (including comparative anatomy), general pathology, general therapeutics, hygiene, surgery, medicine, midwifery, and forensic medicine.

For the degree of M.D.—Candidates to produce certificates: 1, of having taken the degree of Bachelor of Medicine in this university, or a degree in medicine or surgery at a university recognised by this university; 2, of having subsequently attended (A) to clinical or practical medicine during two years in a recognised hospital or medical institution; (B) or to clinical or practical medicine during one year in a recognised hospital or medical institution, and of having been engaged during three years in the practice of his profession; (C) or if he have taken the degree of B.M. in this university, of having been engaged during five years in the practice of his profession; 3, of moral character, signed by two persons of respectability.

Candidates who have not taken a degree in arts, or passed the matriculation examination in this university, will be required to translate a portion of Celsus 'De Re Medicâ.'

Regulations relating to Practitioners in Medicine or Surgery desirous of obtaining Degrees in Medicine.

Degree of Bachelor of Medicine.—Candidates shall be admitted to the two examinations for the degree of Bachelor of Medicine on producing certificates: 1, of having been admitted, prior to the year 1840, members of one of the legally constituted bodies in the United Kingdom for licensing practitioners in medicine or surgery; 2, of having received a part of their education at a recognised institution or school, as required by the charter of the university; 3, of moral character, signed by two persons of respectability.

Degree of Doctor of Medicine.—Candidates who have been engaged during five years in the practice of their profession, shall be admitted to the examination for this degree on producing certificates: 1, of having been engaged during five years in the practice of their profession; 2, of having taken the degree of Bachelor of Medicine in this university.

In Scotland the degree of doctor of medicine is conferred by the universities in Edinburgh, Glasgow, Aberdeen, and St. Andrews, from which last named university a diploma can still be obtained without residence; the regulations at the others contain nothing particularly worthy of notice.

In Ireland, the King and Queen's College of Physicians exercise much the same jurisdiction as the English college. The degrees of Bachelor and Doctor of Medicine conferred by Trinity College, Dublin, rank with the same degrees respectively from Oxford and Cambridge, and are never given without previous study in arts, which occupies four years. For the degree of M.D. five years must have elapsed since the degree of M.B. was conferred; the candidate is then to undergo a second examination, and write and publish a Latin thesis on some medical subject.

By the English law the physician is exempted from serving on juries, from serving various offices, and from bearing arms. He is (according to Willcock, p. 105) responsible for want of skill or attention, and is liable to make compensation in pecuniary damages (as far as such can be deemed a compensation) to any of his patients who may have suffered injury by any gross want of professional knowledge on his part.

In 1858, a new medical act obtained the assent of the legislature, entitled, "an act to regulate the qualifications of practitioners in medicine and surgery." The object of this act was to consolidate the various medical corporations of the United Kingdom, to secure reciprocity of practice throughout the British dominions, and by legal registration independent of the universities and colleges, to secure to the public the means of distinguishing between qualified and non-qualified practitioners. One of the distinguishing features of this act is the constituting a medical council, entitled, "the General Council of Medical Education and Registration of the United Kingdom." This council consists of one person chosen from time to time by each of the following bodies:—

The Royal College of Physicians.
The Royal College of Surgeons of England.
The Apothecaries Society of London.
The University of Oxford.
The University of Cambridge.
The University of Durham.
The University of London.
The College of Physicians of Edinburgh.
The College of Surgeons of Edinburgh.
The Faculty of Physicians and Surgeons of Glasgow.

One person chosen from time to time by the University of Edinburgh and the two Universities of Aberdeen collectively.*

One person by the University of Glasgow and the University of St. Andrews collectively.

The King and Queen's College of Physicians, Ireland.
The Royal College of Surgeons of Ireland.
The Apothecaries Hall of Ireland.
The University of Dublin.
The Queen's University in Ireland.

Six persons nominated by her Majesty by the advice of her privy council, four of whom are appointed for England, one for Scotland, and one for Ireland, and of a president to be elected by the General Council. The first president chosen under this act was Sir Benjamin Brodie, Bart.

The General Council appoints a registrar, who acts as secretary and treasurer.

Branch councils are also appointed for Scotland and Ireland, who have each a registrar, and other officers and clerks.

The act then provides for the registration of every person holding one or more qualifications from the following bodies. The Colleges of Physicians of London, Edinburgh, and Ireland. The Colleges of Surgeons of England, Edinburgh, Glasgow, and Ireland, the Apothecaries Society of London, and the Apothecaries Hall of Dublin, graduates in medicine of any university in the United Kingdom, and graduates of any foreign or colonial university or college practising as a physician previous to the first day of October, 1858. The fee charged for registration under this act is two pounds. The register containing the names and qualifications of all registered practitioners is published yearly.

The Council is given power to require that every university, corporation, or college, whose graduates, members or licenciates are entitled to register, shall cause them to go through such a course of education and examination as shall secure to persons obtaining such qualification the requisite knowledge and skill for the efficient practice of their profession.

Every person registered under this act is entitled according to his qualification or qualifications, to practise medicine or surgery, or medicine and surgery as the case may be, in any part of her Majesty's dominions, and to demand and recover in any court of law with full cost of suit, reasonable charges for professional aid, advice, and visits, and the cost of any medicines or other medical or surgical appliances rendered and supplied by him to his patient. A proviso is made, that it shall be lawful for any college of physicians to pass a bye law to the effect that no one of their fellows or members shall be entitled to sue in manner aforesaid in any court of law, and thereupon such bye law may be pleaded in bar to any action for the purposes aforesaid commenced by any fellow or member of such college.

A clause in this act defines the terms "legally qualified" and "duly qualified" medical practitioner, as meaning a person registered under this act.

Another important provision of this act is in reference to the publication of a common Pharmacopœia for the three kingdoms. Hitherto the Colleges of Physicians of London, Dublin and Edinburgh, have published from time to time their own Pharmacopœias, but the act provides that the General Council shall cause to be published under their direction a book, containing a list of medicines and compounds, and the manner of preparing them, together with the true weight and measures by which they are to be prepared and mixed, and containing such other matter and things relating thereto, as the General Council shall think fit, to be called the 'British Pharmacopœia,' and the General Council shall cause to be altered, amended and republished, such Pharmacopœia as often as they shall deem it necessary.

The passing of this act has caused a very considerable movement in the medical profession. The large body of men who practise in England as general practitioners are members of the College of Surgeons, and practise as and call themselves surgeons. They practise however not only surgery but medicine, and they claim as practitioners of medicine the style and title of physicians. Up to the time of the

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[*] The two universities of Aberdeen have since been consolidated.

passing of the medical act the College of Physicians of London had repudiated the granting their diploma to those who sent out their medicines or practised surgery. But on the passing of this act, those who were registered as physicians by the diplomas of the Colleges of Physicians of Edinburgh or Dublin, were entitled to practise in all parts of the United Kingdom. This, accompanied with the lowering of the fee for admission by the College of Physicians of Edinburgh, led a large number of general practitioners to seek admission to that College. Shortly after the passing of the act, the College of Physicians in London instituted a year of grace, in which they admitted to the membership of the College also at a reduced fee, the graduates of universities and others practising medicine, who did not send out their medicines. This has led greatly to the increase of the number of members of the medical profession, who practise under the style and title of physician.

Some idea of the amount of fees paid to physicians in the middle ages may be gained by what we are told of Petrus de Abano, one of the most eminent physicians of the 13th century. For visiting a patient out of his own city he charged one hundred and fifty francs (or about six pounds) per day; and that when sent for by Pope Honorius IV., he demanded four hundred ducats per day, or about seventy pounds. (Bayle's 'Dict.,' art 'Apone.') It should, however, be noticed that these charges were considered very enormous.

PHYSICIANS, ROYAL COLLEGE OF, the principal chartered medical body in England, was founded through the instrumentality of Linacre, who obtained, by his interest with Cardinal Wolsey, letters patent from Henry VIII., dated in the year 1518. This charter granted to John Chambré, Thomas Linacre, Ferdinand de Victoria, Nicholas Halsewell, John Francis, and Robert Yaxley, that they and all men of the same faculty of and in the city of London, should be in fact and name one body and perpetual community or college; and that the same community or college might yearly and for ever elect and make some prudent man of that community expert in the faculty of medicine, president of the same college or community, to supervise, observe, and govern for that year the said college or community, and all men of the same faculty, and their affairs, and also that the president and college of the same community might elect four every year, who should have the supervision and scrutiny, &c., of all physicians within the precinct of London. The statute 14 Henry VIII. confirmed this charter, and further ordained that the six persons above named, choosing to themselves two more of the said commonalty, should from henceforth be called and cleaped elects; and that the same elects should yearly choose one of them to be president of the said commonalty; and then provided for the election of others to supply the rooms and places of such elects as should in future be void by death or otherwise, which was to be made by the survivors of the same elects. The statute 32 Henry VIII. provides that from thenceforth the President, Commons, and Fellows might yearly, at such time as they should think fit, elect and choose four persons of the said Commons and Fellows, of the best learned, wisest, and most discreet, such as they should think convenient, and have experience in the faculty of physic, to search and examine apothecaries' wares, &c. This last appointment is independent of the constitution of the body, the persons so appointed being officers for a special purpose; and it has been usual to select for this office the same four persons in whom the government of the physicians is reposed by the charter and statute of the 14th of that king.

The constituted officers then of this corporation are the eight elects, of whom one is to be president, and four governors, who have generally borne the name of censors. There is nothing to be gathered from the charter or statutes in any way tending to exclude any of the elects, except the president, from the office of censor; and as no duties are assigned to the elects, except those of filling up their own number, electing one of themselves to be president, and granting testimonials to country practitioners, they may be rather regarded as candidates for the office of president than as active officers of the corporation. The college is bound to choose four censors, for the purpose of discharging the duties confided in it, which are to be executed by these officers. It is also incumbent on the elects to preserve their number, so that there may at no time be less than five, including the president, as they would not, after a further reduction, be capable either of electing a president or choosing others to fill the vacancies in their own body. (Willcock 'On the Laws of the Medical Profession,' p. 32.) It is evident that the charter so far incorporated all persons of the same faculty, of and near London, that every person on the 23rd of September, in the 10th year of the reign of Henry VIII., falling within that description, was entitled to be admitted into the association. Such of them as had availed themselves of this privilege, and others subsequently admitted, are the persons described by statute 32 Henry VIII., as "Commons and Fellows" (quoted in Willcock, p. 13). But as to the persons who should afterwards enjoy that distinction, the original charter and all subsequent statutes are silent. James I. and Charles II. granted charters to this body. The first is silent as to the mode of continuing it; but the charter of Charles, after limiting the number of fellows to forty, directed that when a vacancy should occur in that number, the remainder should elect one of the most learned and able persons skilled and experienced in physic, then of the commonalty of members of the college. Each of these charters seems to have been granted with the view to the enactment of a bill to the same effect, as the kings respectively pledged themselves to give it the royal assent. No statute has been at any time passed in pursuance of this purpose; and it is very doubtful how far and in what manner the charters have been accepted by the college, though they have certainly been several times acted upon. (Willcock, p. 34.)

The licentiates of the college who may practise within the precincts of London and seven miles round it were (until 1836) of three orders, namely, fellows, candidates, and mere licentiates. The last of these classes, generally denominated licentiates, are those who have only a licence to practise physic within the precincts above described. The second class was abolished in 1836. The first class are those who have received that licence, but whose licence also shows that they are admitted to the order of fellows. This licence has often been called a *diploma*, but as it confers no degrees, the word is not properly applied, according to its more strict signification.

The order of licentiates was created by the following clause of the charter of Henry VIII. :—"We have granted also to the same president and college or community, and their successors, that no one within the said city or within seven miles around may practise in the said faculty until admitted to this by the said president and community, or their successors for the time being, by the letters of the same president and college, sealed with their common seal, under the penalty of one hundred shillings for every month for which, unadmitted, he may have practised in the same faculty, half to be applied for us and our heirs, and half for the same president and college." Now the common law having given every man a right to practise in any profession or business in which he is competent, the effect of 14 Henry VIII. must be taken to be this, namely, it has left to every man his common law right of practising in the profession of physic, as in any other profession, if competent, and has appointed the president and college to be judges of this competency. (Willcock, p. 38.) The mode of examination is wholly in the discretion of the college, which has confided the immediate direction of it to the censors. It has, however, also appointed that the doors of the censors' chamber shall be open to all fellows who may think proper to be present, and that they may take part in the examination, should they think fit; and that the fellows may have an opportunity of availing themselves of this right, it is appointed that all examinations shall take place at a court held at certain regular intervals. (Ibid., p. 41.)

The order of Candidates was abolished in 1836, as above stated, but there were reserved to students then in the universities of Oxford and Cambridge their *inchoate* rights.

The order of Fellows comprises those who are admitted into the fellowship, community, commonalty, or society of the college. The charter incorporated all physicians then legally practising in London, so that each of them who thought proper to accept it became *ipso facto* a member or fellow; but as all future practitioners, within the precincts of and seven miles round that city, were required to obtain the licence of the college, there soon arose two orders of the profession. The fellows attempted by various bye-laws to limit their own number, but seem to have considered the licentiates as members of the college, or the commons, and themselves as forming a select body for the purpose of government. To this state of the society, the statute 32 Henry VIII. seems to allude in speaking of the "commons and fellows." The charter of Charles II. expressly notices these orders as forming the body of the society, inasmuch as it directed that new fellows should be elected from among the commons of the society. Ibid., p. 44.)

Up to a very recent period the College confined its election of Fellows to graduates of the universities of Oxford and Cambridge. This was done under the direction of certain bye-laws, which it appeared the College had not by its charters the power to enforce. These bye-laws have been now modified, and graduates of all British and other universities, being licentiates of the College, are open to election for the fellowship.

There is a third class of members of the College, called extra-licentiates, or licentiates *extra urbem*. They are examined by the president and elects of the College, by virtue of an Act of Parliament passed previously to the granting of the present charter of the College. By this Act, power was given to the president and elects to examine persons desiring to practise physic throughout England and Wales. After the College of Physicians obtained their charter this Act fell into desuetude; but the president and elects having made known their power at the beginning of the present century, the list of extra-licentiates gradually increased, till in 1851 they nearly equalled in number the licentiates of the College. By the charter of the College, they were held to have no right to practice their profession within seven miles of London; and in case any of the extra-licentiates came to reside within that distance of London, they were cited to appear and be examined before the censors for their licence to practise in London. This was not a mere formal examination, as instances have been known in which the censors have rejected candidates who had been admitted to practise by the elects. The revival of the class of extra-licentiates by the elects, and the jealousy of the censors of this body of physicians, was one of the causes which led to the passing of the Medical Act of 1858, by which the extra-licentiates obtained the same right to practise in London as the licentiates. It was even doubtful, under the old law, whether the licentiate *intra urbem* had the right to prescribe beyond seven miles of London.

It would be impossible here to give an account of all the literary controversies in which the College of Physicians have been continually engaged, partly in support of their own just and undoubted rights, and partly in defence of their arbitrary and unwise limitations with respect to the election of fellows. A list of the titles of more than fifty pamphlets, &c., written for or against the college between the years 1665 and 1810, is given in a work entitled "An Exposition of the State of the Medical Profession in the British Dominions; and of the Injurious Effects of the Monopoly, by Usurpation, of the Royal College of Physicians in London,' 8vo, Lond., 1826, pp. 373. The following regulations for admission to the licence have been published by authority of the college.

Regulations of the Royal College of Physicians of London—The College of Physicians, having for some years past found it necessary, from time to time, to make alterations in the terms on which it would admit candidates to examination, and license them to practise as physicians, has reason to believe that neither the character nor object of those alterations, nor even the extent of the powers with which it is invested, has been fully and properly understood.

The college, therefore, considers it right at this time to make public a statement of the means which it possesses, within itself, of conferring the rank and privileges of physician on all those who, having had the advantage of a liberal education, both general and professional, can prove their qualifications by producing proper testimonials and submitting to adequate examinations.

Regulations regarding Certificates and Testimonials.—Every candidate for a diploma in medicine, upon presenting himself for examination, shall produce satisfactory evidence—1. Of unimpeached moral character; 2. Of having completed the twenty-sixth year of his age; and, 3. Of having devoted himself for five years at least to the study of medicine.

The course of study thus ordered by the college comprises :—

Anatomy and physiology, the theory and practice of physics, forensic medicine, chemistry, materia medica and botany, and the principles of midwifery and surgery.

With regard to practical medicine, the college considers it essential that each candidate shall have diligently attended, for three entire years, the physicians' practice of some general hospital in Great Britain or Ireland, containing at least one hundred beds, and having a regular establishment of physicians as well as surgeons.

Candidates who have been educated abroad will be required to show that, in addition to the full course of study already specified, they have diligently attended the physicians' practice in some general hospital in this country for at least twelve months.

Candidates who have already been engaged in practice, and have attained the age of forty years, but have not passed through the complete course of study above described, may be admitted to examination upon presenting to the censors' board such testimonials of character, general and professional, as shall be satisfactory to the college.

The first examination is in anatomy and physiology, and is understood to comprise a knowledge of such propositions in any of the physical sciences as have reference to the structure and functions of the human body.

The second examination includes all that relates to the causes and symptoms of diseases, and whatever portions of the collateral sciences may appear to belong to these subjects.'

The third examination relates to the treatment of diseases, including a scientific knowledge of all the means used for that purpose.

The three examinations are held at separate meetings of the censors' board. The *vivâ voce* part of each is carried on in Latin, except when the board deems it expedient to put questions in English, and permits answers to be returned in the same language.

The College is desirous that all those who receive its diploma should have had such a previous education as would imply a competent knowledge of Greek; but it does not consider this indispensable, if the other qualifications of the candidate prove satisfactory; it cannot, however, on any account dispense with a familiar knowledge of the Latin language, as constituting an essential part of a liberal education; at the commencement, therefore, of each oral examination, the candidate is called on to translate *vivâ voce* into Latin a passage from Hippocrates, Galen, or Aretæus; or, if he declines this, he is, at any rate, expected to construe into English a portion of the works of Celsus, or Sydenham, or some other Latin medical author.

In connection with the oral examinations, the candidate is required, on three separate days, to give written answers in English to questions on the different subjects enumerated above, and to translate in writing passages from Greek or Latin books relating to medicine. Those who are approved at all these examinations will receive a diploma under the common seal of the College.

The College gives no particular rules as to the details of previous education, or the places where it is to be obtained. It will be obvious, however, from a reference to the character and extent of the study above described, the manner in which the examinations are conducted, and the mature age of the candidates, as affording full time for acquiring the necessary knowledge, that there will be ample security afforded to the public and the profession that none but those who have had a liberal and learned education can presume, with the slightest hope of success, to offer themselves for approval to the censors' board; and as the College trusts that, by a faithful discharge of its own duty, it can promise itself the satisfaction of thus continuing to admit into the order of English physicians a body of men who shall do it honour by their qualifications, both general and professional, it is prepared to regard in the same light, and address by the same appellation, all who have obtained its diploma, whether they have graduated elsewhere or not.

In drawing up and promulgating the above regulations, the College has endeavoured fairly to look at that which is substantial, rather than that which is merely nominal, in all that concerns the qualifications of its members. It has resolved to estimate all testimonials, whether they are presented under the name of certificates, diplomas, or degrees strictly with reference to their value, and to measure them by this standard alone, as parts of the previous qualification of candidates, which they are to verify in their examinations.

The College feels confident that it has overstepped neither the spirit nor letter of the laws which have invested it with the power of governing and legislating for the whole faculty of medicine within its jurisdiction, by thus earnestly endeavouring to maintain its character and reputation, and vindicate its claim to be the source of professional honour.

Dec. 22, 1838. FRANCIS HAWKINS,
Registrar.

The Medical Act of 1858 [PHYSICIAN] has very considerably modified the position and character of the College of Physicians of London. By giving the right to practise, according to their qualifications, to all practitioners registered under that Act, the exclusive privileges of the fellows and licentiates of the London College were abolished. The College of Physicians of Edinburgh at once opened its doors to all those who, by previous education and examination, were entitled to practise as physicians; and in order to prevent its own extra-licentiates, and those graduates in medicine practising in London and as physicians in the provinces, from obtaining their right to register from Edinburgh, the London College was compelled for some time to admit to its licence, at a fee of ten pounds, all those who were desirous of joining the College. At the same time, and for the same period, the College declared a year of grace for the admission of fellows, and a large number of licentiates were selected for this honour.

The future of the College is still, however, involved in obscurity. Whilst a large number of the fellows are still desirous of maintaining the College as an institution for uniting those only who practise strictly as consulting physicians, there are a number of the younger fellows who are anxious to place the College at the head of the whole profession, by instituting examinations which shall entitle the class of general practitioners to its diploma. Overtures have been made to the College of Surgeons to unite with the Physicians for this purpose, but they have hitherto refused to countenance such a plan. By the new Medical Act, the College of Physicians of London is entitled to apply for a new charter in the following clause :—"It shall be lawful for her Majesty to grant to the corporation of the Royal College of Physicians of London a new charter, and thereby to give to such corporation the name of 'The Royal College of Physicians of England,' and to make such alterations in the constitution of the same corporation as to Her Majesty may seem expedient; and it shall be lawful for the said corporation to accept such charter under their common seal, and such acceptance shall operate as a surrender of all charters heretofore granted to the said corporation, except the charter granted by King Henry VIII.; and shall also operate as a surrender of such charter, and of any rights, powers, or privileges, conferred by or enjoyed under an Act of the session holden in the 14th and 15th years of King Henry VIII., chap. 5, confirming the same as far as such charter and Act respectively may be inconsistent with such new charter. Provided, nevertheless, that within twelve months after the granting of such charter to the College of Physicians of London, any fellow, member, or licentiate of the Royal College of Physicians of Edinburgh, or of the Queen's College of Physicians of Ireland, who may be in practice as a physician in any part of the United Kingdom called England, and who may be desirous of becoming a member of such College of Physicians of England, shall be at liberty to do so, and entitled to receive the diploma of the said College, and to be admitted to all the rights and privileges thereunto appertaining, on the payment of a registration fee of two pounds to the said College." Up to the present time (1860) the College of Physicians has not applied for a new charter.

Much curious information respecting the antiquities of the College of Physicians is to be found in 'The Gold-Headed Cane,' an amusing and interesting little volume by the late Dr. Macmichael. He tells us (p. 120), that its very first meetings, immediately after its establishment, 1518, were held in the house of Linacre, called the Stone House, No. 5, Knight Rider Street, which still belongs to the College. About the time of the accession of Charles I., the College removed to another spot, and took a house of the Dean and Chapter of St. Paul's, at the bottom of Amen Corner. During the civil wars their premises were condemned as part of the property of the Church, and sold by public auction, on which occasion Dr. Hamey became the purchaser, and two years afterwards, 1649, gave them in perpetuity to his colleagues. The great fire of London, 1666, consumed the College and the whole of the library with the exception of 112 folio volumes. For the next few years the meetings of the fellows were generally held at the house of the president, while a new college was being built on a piece of ground that had been bought in Warwick Lane. This was completed in four years, and was opened, without any particular ceremony, on the 25th of February, 1764, under the presidency of Sir George Ent. Here the fellows continued to hold their meetings for about sixty years, when (as Dr. Macmichael says) "the change of fashion having overcome the *genius loci*," the present new college, at the north-east corner of Trafalgar Square, was opened on the 25th of June, 1825, and an elegant Latin oration was delivered by the president, Sir Henry Halford.

PHYSICS. The word *phy'sike* (φυσικὴ), or science of nature, might include in one general term all that is called mixed mathematics, natural philosophy, chemistry, and natural history. The title of physician, or student of nature, has become in our language synonymous with one who investigates the origin of diseases and the means of cure; but in the continental languages it still retains the more general signification. Also physic (the study of nature) has come to mean the drugs given to cure disorders, or medicines; and it would be difficult to name two more complete departures from etymology.

The plural physics is always used to mean the study of nature by means of the severer modes of investigation. Some apply it to the application of mathematics to material phenomena, and to this alone; others, distinguishing the preceding as mathematical physics, include under the general term the sciences of experiment. There is no usage which in any degree approaches a universal reception; we prefer the second-mentioned signification. In this country, the phrase *Natural Philosophy* usually includes all that is understood by the term *Physics*.

PHYSIOGNOMY (φυσιογνωμονια) is the art of determining the mental character of an individual by the examination of his countenance. The popular ideas of the indications afforded by different kinds of features, by the adoption of which almost every one is at times a practitioner of physiognomy, are nearly as definite as the few principles which those who have made it an object of peculiar study have established. The circumstance on which the chief and surest indications afforded by the countenance depend, is, that when certain feelings and habits are much indulged in, the positions of the features which are associated with them are apt to become permanent, either by the formation of wrinkles or other marks in the skin, or by the enlargement and disproportionate strength of the muscles chiefly exerted. Thus a person in the frequent habit of sneering contemptuously acquires at last a slight curve in his upper lip by the disproportionate size and power of its elevator muscle; he who is often meditating has the wrinkles of the slight frown and the contraction of the brows which are commonly associated with deep thought, permanently fixed; he who has his attention constantly alive to the objects around him acquires an expression of vivacity in the openness of his eye and the quickness of the motions of all the muscles of his face; while he, on the other hand, whose thoughts are rarely roused to active efforts, acquires a smoothness of feature and a sluggishness of action in the several parts of the face, which indicate that its muscles have been exercised as rarely and with as little energy as his thoughts.

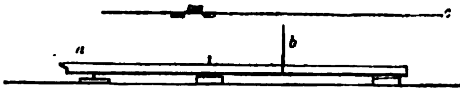
The peculiarities of feature thus acquired are often transmitted from the parent to the child; and in the latter, their indications will be correct or false according as there has or has not been a coincident transmission of the parent's disposition. Or a child may acquire a peculiar expression of countenance by imitating those among whom it is placed, and in this case also it will only be by accidental coincidence that the indications of the features are correct. From these and other sources of fallacy, the attempts to raise physiognomy into a science have not been so successful as to encourage a deeper study of it than every one unconsciously engages in during his intercourse with the world.

PIANO-FORTE, a keyed musical instrument, variously formed and under different denominations, such as *grand*, *semi-grand*, *square*, *cabinet*, *cottage*, &c. The first notion of the square piano-forte was taken from the clavichord by a German mechanic of the name of Viator, more than a hundred years ago; but, for want of friends or funds, he never became known as a maker. The invention, however, was followed up by other musical instrument makers of the same nation, who all ceased to produce clavichords and harpsichords, and directed their attention to the new instrument, the piano-forte. Thus we have Zumpe, Tabel, Schudi, Kirkman, Stodart, Schoene, Buntebart, Pohlman, Pether, Beck, Garcha, Ganer, and a host of others.

The grand piano-forte is supposed to be of earlier date than the square piano-forte, and is said to have been the invention of a German musician of the name of Schröder, or, as others say, of Christofali, a harpsichord-maker of Padua. The first maker at all known in this country was Backers; but we are not aware that success attended his exertions with the solid advantages which were enjoyed by his contemporary Zumpe, who realised an ample fortune and retired. The grand piano-forte retains the shape of the instrument from which it was taken, the harpsichord; and although that shape has been much condemned, it is the natural outline of the instrument; and we do not think that a better form for it will ever be devised.

The square piano-forte, we have said, was taken from the clavichord, but it retains only its shape, with the same disposition of the strings and keys; their actions have no similarity. We must here explain that the *action* of all such instruments is a technical name for all the mechanism which intervenes between the outer ends of the keys on which the fingers press, and the strings which emit the sounds; to describe the action, therefore, is to describe the essential parts of the instrument. The action of the clavichord was simply a piece of brass pin wire, which was placed vertically at a point where it could be struck or pressed against its proper strings. Each note had two strings. The right-hand string was free to vibrate; whilst that on the left-hand was muffled by a piece of cloth, the object of which was to damp or stop the string the instant the finger was taken off the key. The touch of the clavichord was peculiar, partaking both of the harpsichord and the organ; in other words, both *struck* and *pressed*, and the pressure could be so varied as to produce a kind of tremblant effect. The tones were feeble, soft, and melancholy, and better suited to the student, the composer, or the solitary, than any purposes of social amusement. A vertical section of this action is shown in *fig.* 1.

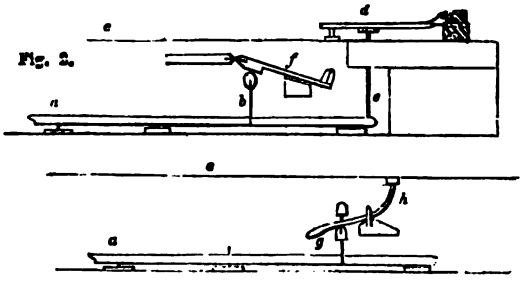
Fig. 1.



a, Key; *b*, Brass pin wire; *c*, String; *d*, Cloth woven between the strings as a damper.

The action of the square piano-forte, on its first introduction, consisted of a *key*, a *lifter*, a *hammer*, and a *damper*. The key was the same as that of the clavichord. The lifter was a brass wire, with a piece of hide leather as a head, which was covered with a piece of soft leather as a finish. This lifter, when in motion, struck the hammer against the string, and thus produced the tone of the instrument. The damper followed, and stopped the vibrations as quickly as the finger was removed from the key. (*Fig.* 2.) The tone of this piano-forte was thin and *wiry*, the hammer having only one slight covering of sheep-skin leather upon it.

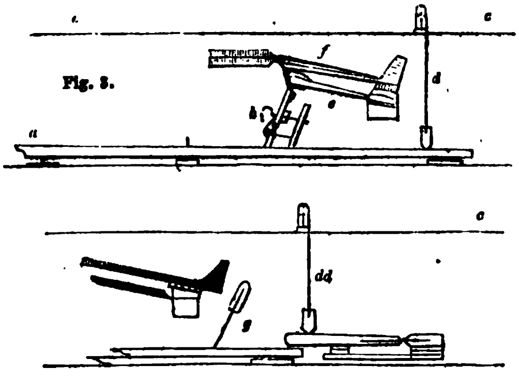
Fig. 2.



a, Key; *b*, Lifter; *c*, String; *d*, Damper; *e*, Damper stick or *mopstick*; *f*, Hammer; *g*, Lifter; *h*, Brass damper.

This rude idea of a piano-forte continued in use for many years. The first improvement upon it was introduced by Longman and Broderip, who brought out a patented invention having two additional parts in the action, namely, the *hopper* and the *under-hammer*, as they were called (*fig.* 3.) This patent was followed by another introduced by Clementi & Co., the burden of which simply was an improvement on the damper. It was called the *Irish patent*, from its having been the invention of an Irishman of the name of Southwell; but it had simplicity only to recommend it, was found inconvenient, and shortly afterwards was superseded by what is now called the *crank* damper. We cannot give the name of the inventor of this improvement; it became so instantaneously general, that the inventor was lost sight of in the crowd of makers who adopted his invention. It is still in use, and is acknowledged to be a good and sufficient plan. The damper used by Messrs. Broadwood previously to the introduction of the crank damper was made in brass (*fig.* 2), but by whom invented we do not know. We now come to the last addition which has been made to the action of the square piano-forte, the *check*. This member was borrowed from the grand piano-forte, and is so acknowledged by the name given to those square piano-fortes which have it; for they are always called, par excellence, *grand-square piano-fortes*. The check certainly is a most important part of a piano-forte, and the best of actions is nothing without it. The check is placed behind the hammer, nearly at the end of the key; where, after the blow has been given, it catches the tail of the hammer, and holds it till another is required (*fig.* 3). For further information as to the square piano-forte, we refer to the diagrams. The square piano-forte has neither the touch, the tone, nor the appearance of either the grand or the upright.

Fig. 3.

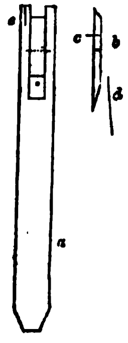


a, Key; *b*, Hopper, by which the escape of the hammer is effected; *e*, String; *d*, Irish damper; *dd*, Crank damper; *c*, Under hammer; *f*, Hammer; *g*, Check.

The grand piano-forte, as above observed, was the invention of Schröder or Christofali, manufactured by Backers, and retains the shape of the instrument from which it was taken, the harpsichord. Here again we have two instruments alike in *form*, but unlike in almost every other circumstance; for their action, their tones, and the style in which they are played upon, are all entirely different. The action of the harpsichord was simply a key and what was called a *jack*, a piece of pear-tree with a small moveable tongue of holly, through which a cutting of crow-quill was passed to touch the string when the jack was in action; the tone produced by this contrivance was a kind of *scratch* with a sound at the end of it.

Harpsichord Jack.

Fig. 4.



a, Jack; *b*, Tongue; *c*, Quill; *d*, Bristle-spring; *e*, Cloth damper.

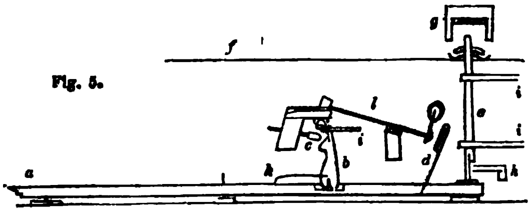
The action of a grand piano-forte consisted of a *key*, a *lever*, a *hammer*, a *button*, a *check*, and a *damper*, with rails and sockets to connect them. By this combination of parts, every musical intention known or desired at that time was perfectly attainable, and with admirable effects by Mozart, Haydn, Cramer, and others. But we have now new and more severe judges to encounter: former actions are no longer sufficient; new effects are to be given, and new powers are called for. Fortunately, these things have been accomplished; for new actions have risen up in abundance, and we have only to choose between them.

No musical instrument is so universally admired as the piano-forte. Its compass, whether six octaves, six and a half, or seven, is sufficient for all purposes of musical composition, and may really be considered a miniature orchestra. The strings of the early piano-fortes were partly of steel and partly of brass—the treble notes of steel, and the lower notes of brass—a few of which, in the bass, were over-lapped or covered, rather open, with plated copper-wire to give them more gravity according to the length attainable in the instrument. But modern piano-fortes have steel wire throughout, with about an octave in the bass closely lapped with unwashed copper wire. The strings which are now used in piano-fortes are considerably larger than those formerly used, to give durability and firmness. The once-famed German wire is now no more in esteem with English manufacturers, from the bad quality of the metal and the very imperfect manner in which it was drawn; when perfectly round, which it ought always to be, it was generally too soft; and when sufficiently hard, it was scarcely ever well manufactured, from which circumstance it was constantly false in vibration. Steel-wire for piano-fortes, of very excellent quality, is now made at Birmingham. Stops and pedals are more or less adopted in different countries. Stops can scarcely be said to be used at the present day; they properly belong to the middle age of piano-forte making, and were placed in the instrument on the left hand of the performer. The damper-stop and the buff-stop were the most common; the damper-stop raised the dampers from the strings, which gave continuation to the tones; and the buff-stop raised a piece of soft buff leather up to the strings, and gave the instrument somewhat the tone of the harp. Pedals are much esteemed by some performers and little by others; in foreign piano-fortes we find many pedals, but in the English we have scarcely ever more than two—one for piano effects, and the other for forte. This pedal, the forte, is an effective pedal, and not at all injurious to the mechanism of the instrument; we cannot say as much of the piano pedal, for by passing the action to one string, it is not only straining to the centres of the hammers, but is also very apt to disturb the tuning of the unisons, by which an instrument is often unfairly tested as regards its standing, and a more frequent application to the tuner is required. In lieu of this pedal, some makers have introduced a soft substance, wool or leather, between the hammers and the strings, by which something like the buff-stop is accomplished, but with more delicacy and vibration in its effects. The foreign name for this pedal is *jeu céleste;* and to us it is more agreeable, and is certainly less injurious to the action of the instrument, than the more frequent piano pedal.

We will here give a few diagrams of grand actions.

The Common Grand Piano-forte Action.

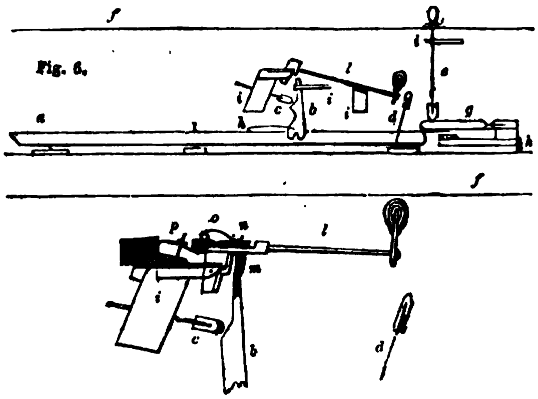
Fig. 5.



a, Key; *b*, Lever; *c*, Button; *d*, Check; *e*, Damper; *f*, String; *g*, Ruler; *h*, Damper pedal lifter; *i i i*, Rails and sockets; *k*, Spring; *l*, hammer.

Broadwood's earlier and later Grand Actions.

Fig. 6.

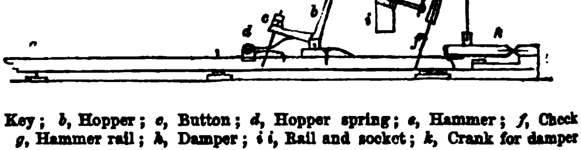


The shaded parts are the new additions, the intention of which is to keep the hammer at a certain distance from the string when the finger is on the key.

a, Key; *b*, Lever; *c*, Button; *d*, Check; *e*, Damper; f, String; *g*, Crank for damper; *h*, Damper pedal lifter; *i i i i*, Rails and sockets; *k*, Spring; *l*, Hammer; *m n*, Block passed through the hammer butt; *o*, Spring fixed at the back of *n*, and pressing upon the front of it; by which arrangement, when the lever passes the notch, it is caught by *m*, and the hammer is sustained at the given height; *p*, Another spring, which regulates the action of *o*, and determines the height it shall rise.

Collard's Grand Action.

Fig. 7.



a, Key; *b*, Hopper; *c*, Button; *d*, Hopper spring; *e*, Hammer; *f*, Check; *g*, Hammer rail; *h*, Damper; *i i*, Rail and socket; *k*, Crank for damper; *l*, Damper pedal lifter.

Erard's Grand Action.

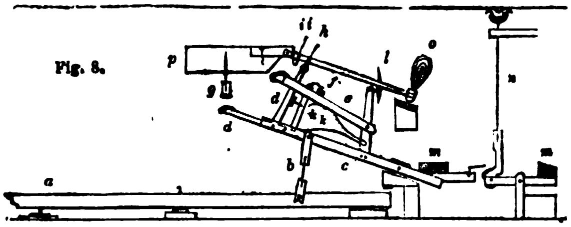


Fig. 8.

a, Key; *b*, Lifter centred in the key and the hopper lever; *c*, Hopper lever; *dd*, Hopper; *e*, Hammer sustaining lever; *f*, Stop for *e*; *g*, Hopper button; *h*, Butt for the hopper to hit against; *i i*, Two small wire stops acting upon *e*; *k k*, Hopper and sustaining spring; *l*, Check; *m m*, Balance weights of lead; *n*, Damper; *o*, Hammer; *p*, Hammer rail.

Wornum's Grand Action, based on the Piccolo Action.

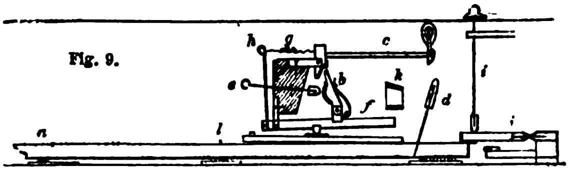


Fig. 9.

a, Key; *b*, Hopper and spring; *c*, Hammer; *d*, Check; *e*, Button to set off the hopper; *f*, Hopper lever; *g*, Tie attached to the butt of the hammer; *h*, Sustaining spring linked to the end of the tie, and fixed in the front end of the hopper lever, the rising of which puts the sustaining spring in action. This spring gives the *piano* blow and assists in the *forte* and repetition; *i i*, Damper and fixings; *k*, Hammer ruler and back touch; *l*, Wood spring to set up the hoppers.

Zeitter's Grand Action.

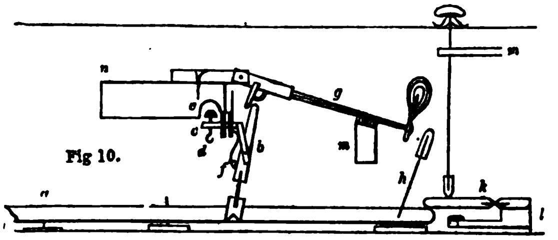


Fig 10.

a, Key; *b*, Hopper, which works in the key with what is called a *bird's mouth*; *c*, Escapement part of the hopper and the setting off is effected by the button working in the arched part above it, *d*, *e*; *d*, Button and wire; *e*, Arch in which the button acts; *f*, Hopper spring; *g*, Hammer; *h*, Check; *i*, Damper; *k*, Damper crank; *l*, Damper pedal action; *m m*, Rail and socket; *n*, Hammer rail.

Some of the above-named makers have patented still more recent actions for grand piano-fortes, as also have other makers not here named.

The *upright* piano-forte was, doubtless, taken from the upright harpsichord; it was the invention of an Englishman of the name of Hancock, a musical instrument maker resident in some part of Westminster. He was a man of much ingenuity, and produced several varieties in keyed instruments; amongst which we find the *organised piano-forte*, the *portable grand* piano-forte, and an instrument, also a piano-forte, in the shape of a *spinnet*. The portable grand, in its day, was a successful and desirable instrument, but has long since been superseded by instruments of the kind called *kit* grands, *boudoir* grands, *pocket* grands, and *semi* grands. The next novelty was the invention of John Isaac Hawkins, who constructed an upright instrument with a detached sound-board in an iron frame; and the whole was so arranged as to be able to meet the atmosphere with compensating powers. In the bass it had spiral or helical strings, by which length was gained; and, in the treble, three octaves of equal tension were accomplished by a uniform size of wire. It was patented, but did not take with the public sufficiently to come into notice. Following Hawkins' we had William Southwell, who patented an improvement in upright piano-fortes, and gave it the name of the *cabinet piano-forte*. The name still remains amongst us, but the invention has long since been superseded and laid aside. The *unique* piano-forte was introduced about fifty years ago by Messrs. Wilkinson and Wornum, and was the invention and patent of the latter. This instrument met the taste of the day for instruments of *little altitude;* it did not stand higher than *three feet three inches*, and the strings were all placed *diagonally* towards the floor. The action was simple and effective, but it is not now under manufacture.

Wornum's Patent Unique Action.

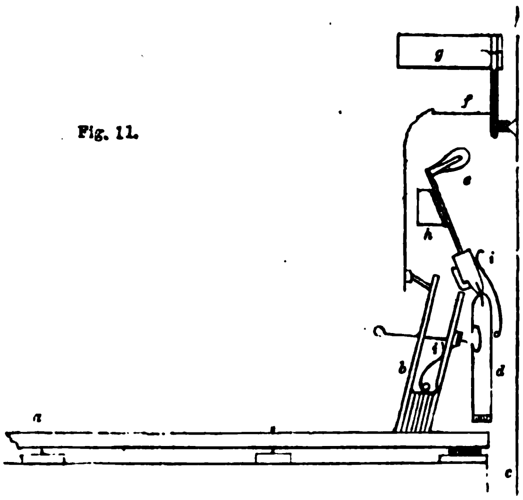


Fig. 11.

a, Key; *b*, Hopper; *c*, String; *d*, Hammer rail; *e*, Hammer; *f*, Damper and wire; *g*, Damper rail: *h*, Ruler; *i i*, Springs.

Numerous inventions and improvements appeared from time to time. One of these was Mr. Wornum's *double* or *piccolo action*, applicable to both upright and horizontal instruments; and another was the *cottage* form, now so much in use.

Wornum's Double or Piccolo Action.

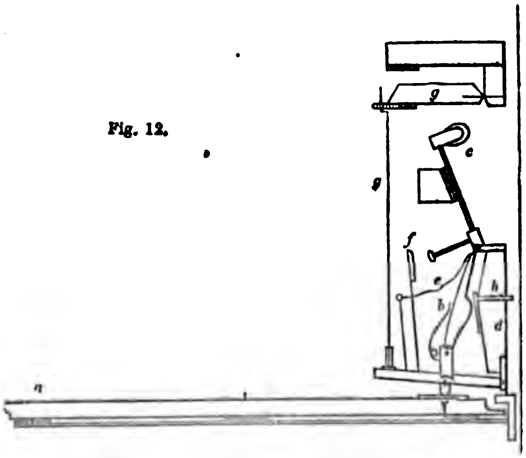


Fig. 12.

a, Key; *b*, Hopper and spring; *c*, Hammer; *d*, Hammer rail; *e*, Tie and wire; *f*, Check; *g g*, Damper and wire; *h*, Setting off screw.

There are many things relating to the piano-forte which we have not touched upon. There are also some foreign actions to which we have not given much attention, especially those called *down-striking* actions. Other inventions, too,—such as Mr. Litherland's patent helical springs to preserve the tuning, Mr. Riley's transposing instrument, Mr. Mott's sostinente, Mr. Kirkman's octave string, and Mr. John Trotter's alternated key-board,—have all given place to other things, and are no longer known to the present generation of musical people. Mr. Litherland's plan was a well-tempered *helical spring*, which was to be attached to the loop of the string; thus, as the string contracted the spring gave way, or as it expanded the spring collapsed, by which the pitch of the string was retained and the tuning consequently preserved. It was never adopted to any great extent, but had its admirers: a want of firmness in the tone was perhaps its greatest defect. Mr. Riley's plan for *transposition* was simply a double set of keys, one sliding under the other, by which music might be played from the same scale a note or notes *higher* or *lower*. It was purchased by Messrs. Broadwood, and is now laid aside. It never was calculated to be of service to the practice of music; neither did it introduce any new or valuable idea to the mechanic. Mr. Mott's *sostinente* was an application of a cylinder and silk loops to an upright piano-forte. The loops were attached to the strings, and the cylinder, which was moved by the foot, as it were *bowed* them, and the tones came forth somewhat like the tones of the seraphine. Under Mr. Mott's fingers, this instrument was capable of most pleasing effects; but without such aid, we never esteemed the invention. Mr. Kirkman's *octave string* was applied as the third string of a grand piano; this string was an octave higher in pitch than the other two, and was somewhat in effect like two diapasons and a principal in an organ, but not so marked in character. It pleased for a time, but is now no more thought of. In Mr. Trotter's *alternated key-board* the peculiarity was that of alternating the keys: thus the octave came within seven white keys; the black keys, too, were passed *under* the *white*, and finished in front of them *below* with *broad heads;* by which arrangement a black key could be taken by either the *thumb* or the *finger*, at the option of the performer. This instrument was called by Mr. Trotter a *transposing piano-forte*; and he went so far as to promise a *new notation* for it, which notation he seemed to think would do away with the present altogether. That he did not live to perform his promise we much regret; for, certainly, double sharps and double flats, with all their accidentals, are anything but agreeable to those who cannot devote their whole lives to the study of music.

In relation to the *bracing* of piano-fortes, there is a difficulty in giving strength to that of the squares and grands. Some makers are for iron, and some for wood; but wood, it seems, is inconvenient, and iron is therefore mostly adopted. That strength is important, and very important, is quite clear, when we know that the strings of a grand piano-forte pull equal to a weight of *six tons*. Iron as a substance, doubtless, has the greater strength, but may not wood be so applied as to be strong enough? That wood is more sonorous than iron, there has never, we believe, been a question; and we will yet hope that, sooner or later, it will be allowed to be a better material.

The piano-forte manufacture is now conducted in this country on a very large scale, and comprises processes of the highest order in the working of wood. The recent cheapening of the instruments has resulted in part from the lessening of profits, by the establishment of a number of small manufactories in competition with the few older firms. But it remains nevertheless true, that a large capital, aided by highly-paid workmen's skill, are necessary for the production of the best instruments. Such firms as Broadwood's, Collard's, &c., keep timber in store for many years, and bestow extraordinary care upon it, that it may be perfectly seasoned before being used. Specimens of wood of more than usual beauty are eagerly bought by such firms at enormous prices: an example of this has been noticed in the article MAHOGANY. Some of the piano-fortes now made, having the most complex and elaborate actions, consist of very little less than four thousand separate and distinct pieces, each of which, according to its material and character, has to be carefully fashioned before being adjusted to its place. The material thus used comprises ivory, ebony, cedar, sycamore, lime-tree, pine, and oak, according to the kind of service required; besides the mahogany, rosewood, or walnut-wood of the exterior; and besides steel, iron, brass, lead, cloth, felt, leather, and vellum.

The great extension of piano-forte music in families, and the unceasing demand in the Australian and American colonies, have led to a notable extension of the piano-forte manufacture within the last few years.

PIASTRE. [MONEY.]

PIAZZA, a term adopted in its original form from the Italian, but with a great change of its meaning; for while in that language it signifies merely an open place, it is employed by us to denote a covered ambulatory, whether formed by columns or arches, in the lower part of a building, such cloistered walks being very common in the *piazze* or public squares of Italian cities, as that of St. Mark's at Venice, &c. Yet, although we have borrowed the term, it has been rather as a distinct name applied in a few particular cases, than as a general denomination; for Inigo Jones's arcade, on the north and part of the east side of Covent Garden, which is expressly called the "Piazza," is the only example, except on a very small scale, that we can refer to in London.

PIBROCH, in Scottish music, the march or battle-tune of the Highland clans.

PICAMAR. [TAR.]

PICHURINSTEARIC ACID. [LAURYL; LAURIC ACID.]

PICOLINE ($C_{12}H_7N$), is a volatile oily base, isomeric with aniline, and found in coal tar. It has very powerful basic properties, and is probably the same substance as the *odorine* described by Unverdorben.

PICRAMIC ACID. [PHENYLIC GROUP.]

PICRANISIC ACID. [PHENYLIC GROUP.]

PICRIC ACID. [PHENYLIC GROUP.]

PICROLICHENIN. A colourless crystalline bitter body, found in the *variolaria amara*. It fuses below the boiling point of water, and is insoluble in water, but very soluble in alcohol and ether. Its exact composition is not known, but it does not contain nitrogen.

PICROTOXIN ($C_{10}H_6O_4$). The active principle of *cocculus indicus*. It crystallises in white quadrilateral prisms, is neither acid nor alkaline, but has an intensely bitter taste. It is excessively poisonous; one-third of a grain introduced into the stomach of a cat produced tetanic convulsions and death in ten minutes.

PICRYL ($C_{42}H_{15}NO_4$) is yielded by the distillation of the product obtained by acting on oil of bitter almonds with sulphide of ammonium. By the action of nitric acid it is converted into *trinitropicryl* $C_{42}\left\{\begin{matrix}H_{12}\\3\,NO_4\end{matrix}\right\}NO_4$ which is a yellow crystalline powder.

PICTS, an ancient people of North Britain, whose origin and history are singularly obscure, and have furnished matter for endless speculation and controversy. The name does not occur in the enumeration of the British tribes given by Ptolemy in the beginning of the 2nd century; nor are the Picts noticed by his successors Dion Cassius and Herodian, the latter of whom wrote about A.D. 250, any more than they are by his predecessors Julius Cæsar and Tacitus. This has not prevented some writers from maintaining that the Picts were settled in Britain before Cæsar's invasion; that is, for instance, the opinion of Pinkerton; but it is certainly at least in the highest degree improbable that they should have been passed over by Ptolemy if they were here in his time. The earliest mention of them by any ancient writer occurs in an oration addressed by the rhetorician Eumenius to the emperor Constantius Chlorus, on his return from his victory over the usurper Allectus, in the year 296. Eumenius there speaks of the Britanni in the time of Julius Cæsar (according to the best reading of the passage) as "Solis . . . Pictis modo et Hibernis adsueti hostibus" —having been used only to the Picts and Irish as enemies.

After the time of Eumenius we have frequent mention of the Picts in the Roman writers. Ammianus Marcellinus, under the year 360, speaks of the invasion of the borders of the Roman province in Britain by those wild nations the Scots and Picts—"Scotorum Pictorumque, gentium ferarum." Again, in 364, he enumerates the "Picti, Saxonesque, et Scotti, et Attacotti," as harassing the Britanni with incessant attacks. We may just observe that the Scoti or Scotti mentioned in these two passages were in all probability not yet inhabitants of any part of Britain any more than were the Saxones. But the most important passage in Marcellinus relating to the Picts, although it refers to another probably still more important, which is unfortunately lost, occurs in his annals of the year 368, where he says that, in relating the actions of the emperor Constans (A.D. 337-350), he had already described as well as he could the situation of Britain, and that therefore it is necessary for him only to observe now, that at that time "Picti, in duas gentes divisi, Dicaledonas et Vecturiones, itidemque Attacotti bellicosa hominum natio, et Scotti per diversa vagantes, multa populabantur." It thus appears that about the middle of the 4th century the Picts were understood to be divided into two tribes, the Dicaledonæ, or Dicaledones, and the Vecturiones. These two names have however occasioned much perplexity. The Vecturiones, or Vecturones, indeed, are mentioned by Richard of Cirencester, whose work however is possibly nothing more than a modern forgery; but the name Dicaledones occurs nowhere but in this passage of Marcellinus. Skene ('The Highlanders of Scotland, &c.,' 1837) maintains that the Picts and Caledonians were the same. The Vecturiones are admitted to be Picts, and if for Dicaledones we should read, as has been proposed, Deucaledones, the meaning of which is "genuine Caledonians," as in Du Albinnach, a genuine Scotsman, the two tribes would appear to include the whole population.

It is very doubtful indeed in how far we are to understand the Roman writers as meaning at all the same people we now call the Picts by their term *Picti*. That term seems always to have been used by them in the sense simply of painted men, rather than as the name of any particular people. At least this notion, which we find Claudian indicating in his "nec falso nomine Pictos" ('De Text. Cons. Honorii'), and in other passages, seems always to have been suggested to them by the name, and to have therefore induced them to apply it loosely to all the wild inhabitants of the north of Britain who were in the habit of painting their bodies, or rather among whom they supposed that practice to exist; and they were probably the descendants of a primitive race, or the oldest of which we have any trace, the Albiones of Festus Avienus, and the Albinnach of the Welsh and native writers. Moreover, a derivation has been more recently traced in the Welsh *peith*, to fight or scream, whence *pic-t-a*, a fighting man.

That there was in early times a people settled in North Britain bearing a name of which the Latin *Picti* was intended as the representative, may be pronounced to be a fact only to be disputed by that sort of scepticism which is not less hostile to the investigation and establishment of historic truth than the weakest credulity. They are mentioned under the name of Picti not only by Eumenius, Marcellinus, Claudian, and other Roman writers, but by Gildas, Nennius, Bede, and Paul Warnfrid (Paulus Diaconus), all of whom lived while the Pictish kingdom still subsisted in the country now called Scotland; Bede even gives a history of the first settlement of the Picts in North Britain, which may be correct or not, or partly truth, partly fable, but which agrees in some remarkable points with the accounts both of the Irish and of the Norwegian or Icelandic annalists; the Saxon Chronicler and other contemporary writers of that nation speak of them under the names of *Peohtas, Pyhtas, Pihtum*, and *Pehiti;* the Welsh historical fragments call them *Phichtjaid;* the Icelandic writers, *Pets;* the ancient Irish annalists, *Cruithne* for the northern Picts, while the southern were called *Piccardach*, names which are sufficiently ascertained to indicate the same people: and popular tradition in Scotland still remembers them under the name of *Peche* (pronounced with a deep and prolonged guttural intonation), which is probably as near their true name as any of the other forms.

The main dispute with regard to the Picts, as with regard to the Caledonians, with whom they have been sometimes identified, the Scots, the Cimbri of antiquity, and the Cymry or modern Welsh, the

Belgæ and the Irish Firbolgs, has been, whether they were a Celtic or a Teutonic people. Their Teutonic lineage is maintained by Usher, Stillingfleet, and Pinkerton; that they were Celts is the opinion of Camden, Bishop Lloyd, Father Innes, George Chalmers, Ritson, and others. The historic evidence that bears upon the point does not amount to much; all that can be said is, that the various old legendary accounts all make them to have come to Britain from Scythia or from Scandinavia. But the most curious and valuable fact that we possess in relation to this matter is, that their language appears to have nearly resembled the Welsh, and the Welsh Triads uniformly term them *gwyddyl Ffichti*, the Gaelic or Celtic Picts. One Pictish word only has been expressly mentioned by any old writer. *Peanvahel*, Bede tells us, was the Pictish name of the place at which the wall of Antoninus terminated on the Forth, and which Nennius says was called in Welsh *Pengaaul* (Pengual?), and in Scotch (*Scotice*) *Cenail*. It is still in fact known by the name of Kinneil. *Cen*, or *Cean*, is the Irish or Gaelic word for a head, and Cenail in that dialect would mean the head of the wall; and that is also the signification of the Welsh name, with which the Pictish is evidently identical. It is remarkable that in Angus, and the other counties on the north-east coast of Scotland where the Picts were longest established, the popular speech is still characterised by the peculiarity of the substitution of the element *f* for *w*, or *wh*, or *gw*. Thus, for *what* the people of that district all say *fat*, just as their Pictish ancestors for Pengual said Penfahel or Penfal. And generally it appears that the ancient names of places in those parts of Scotland formerly occupied by the Picts are Welsh, as was long ago pointed out by Camden, and afterwards more fully established by George Chalmers, in his 'Caledonia;' and has been substantiated by most subsequent investigations.

The greatest diversity of opinion has also prevailed as to the extent of the territory occupied by the Picts in the north of Britain. Pinkerton, who considers the Picts to be the same people with the Caledonians, holds them to have occupied not only the Orkney Islands and the Hebrides, but the whole of Scotland to the north of the Friths of Forth and Clyde, and to have extended their conquests on the east coast as far south as to the Humber. There is every reason indeed to believe that they were at one time in possession of a considerable territory to the south of the Forth. Bede expressly states that in his time the English held possession of the Pictish province in which stood Aebbercurnig, now Abercorn, in West Lothian, the seat of one of their bishops. Here too was Peanvahel, now Kinneil; and Edinburgh, farther to the east, on the same side of the Forth, is also described by old writers as having been at one time within the dominion of the Picts. But, at least during the greater part of the time that it subsisted, the Pictish kingdom appears to have been bounded by the Frith of Forth to the south, and to the west by the mountainous range still separating the Lowlands from the Highlands of Scotland. The kingdom of Strath-Clyde, or Cumbria, however, or Reged (that is, the kingdom, by way of pre-eminence), as it was usually designated by the Welsh, which comprised the south-west of Scotland, and perhaps also the county of Cumberland (if that did not form a separate state), must be regarded as having also been Pictish on the hypothesis which assumes the Picts to have been the same people with the Welsh, the latter being admitted on all hands to be of the same race with the people of Strath-Clyde.

The history of the Pictish kingdom established in the north-east of Scotland is, as may be supposed, exceedingly scanty and obscure. The Scottish and Irish chronicles however supply five different lists of the Pictish kings, no one of which evidently has been copied from another, although they all agree substantially, with the exception of such variations as tend to establish the independent authority of each. From these lists Pinkerton has framed a Pictish chronology, which he divides into two portions: the first, which he entitles Poetical, extending from the foundation of the monarchy by Cruthen, or Cruithne (whence the Irish name for the northern Picts), about A.D. 28, through a succession of thirty-six kings, ending with Talorc I., A.D. 414; the second, styled Historical, extending from the accession of the successor of Talorc, Drust the Great, through forty princes more, to the subversion of the monarchy in A.D. 843, in the reign of Brudi VII. Besides the succession of the kings, a few events of Pictish history are also recorded by the Irish and Icelandic, as well as by the less ancient Scottish chroniclers. These consist chiefly of the foundations of a few towns, and of battles fought with the Scots, or Irish colonists of the north-west of Scotland, with whom the Picts appear to have been almost constantly at war from the first establishment of these new settlers in the country about the beginning of the 6th century. Bede and Ailred state that the Southern Picts were converted to Christianity by St. Ninian about the year 412; but it may be doubted whether these were the Picts living between the Forth and the Grampians, as Bede affirms, or the people of Strath-Clyde, among whom it is known that Ninian was established as bishop of Whithern, now Whitehorn, in Wigtonshire. The conversion of the Northern Picts is attributed to St. Columba, about the year 565.

No passage of the obscure story of the Picts is involved in greater darkness than the sudden catastrophe which appears to have put an end to their dominion in their principal seat, the north-east of Scotland. The common account of the Scottish historians is, that the Pictish kingdom was conquered in the year 843 by the Dalriadic or Scottish king Kenneth II., who thus, for the first time, united the whole of North Britain into one monarchy. The oldest authorities for this account are the Chronicon Regum Pictorum, written apparently about the beginning of the 11th century (it comes down to the year 992), and first published by Father Innes, in 1729; and the Register of St. Andrew's, written about 1180. On the other hand it is extraordinary that no allusion should be made to any revolution as having taken place in Pictland about this time, either by Nennius, who wrote about 858, and who expressly states that the Picts then continued to hold a third part of Britain; by Asser, the biographer of king Alfred, who wrote before the end of the same century, and who speaks of the Danes ravaging the Picts in 875; by the Saxon Chronicler, by Ethelwerd, or by Ingulphus, who, in the 10th and 11th centuries, all continue to speak of the Picts as an existing people; by the Irish annalist, Tighernac, who wrote about 1088, and who continues a regular chronicle of the Pictish kings, among whom he reckons Kenneth himself, down to the death of his son Constantine II., in 875; by the Welsh annalists, who, in like manner, style Kenneth simply king of the Picts; or finally, by the singular genealogical poem, commonly called the Gaelic or Albanic Duan, belonging to the reign of Malcolm III. (1056-1093), which passes over the reign of Kenneth II. without any remark; though it states that the Cruithne had gone from Ireland, and seventy kings had possessed the Cruithne plains. It thus appears that neither the Irish, the Welsh, nor the Saxon annalists who lived nearest to the time, ever heard of this subjugation of the Picts by the Scots, which the later Scottish chroniclers would have us believe amounted to the entire destruction of the Pictish nation, and indeed to the utter extirpation of that people from the soil of Scotland. Nevertheless, the fact remains unquestionable and undisputed, that Kenneth II., or Kenneth Macalpin, as he is commonly called, having been originally king of the Scots, or Dalriads, became king of the Picts about the date assigned to his conquest of that people; and the probability therefore seems to be that this Dalriadic king had a claim by descent to the Pictish throne, and that the contest in which he proved victorious was in fact not a war between the Scots and Picts, but merely a dispute between him and a rival claimant for the crown of Pictland, which terminated in its acquisition by Kenneth, and consequently in the union of the two kingdoms under one sceptre. The two people also were of allied races, and might have easily amalgamated. Kenneth, we may here notice, appears to have followed up this success by a course of policy having for its aim the ultimate incorporation with his own dominions of the adjoining (perhaps Pictish) kingdom of Strath-Clyde; and that object was in fact accomplished, and the whole of what is now called Scotland brought (nominally at least) under one rule, in the year 973, in the reign of his great-great-grandson Kenneth III. Even down to a considerably later date than this, however, a great part of the north-east of Scotland appears to have been actually held by Norwegian princes, who did not acknowledge the sovereignty of the descendants of Kenneth Macalpin; and even some of the great Highland chiefs of the west long continued to maintain almost as substantial if not as openly avowed an independence.

Certain singular architectural remains found in some parts of Scotland are still popularly known there by the name of Picts' houses: and the Picts, or Pechs, live in the traditions of the country as a people of almost superhuman strength and dexterity. This would seem to indicate the possession by that race of a more advanced civilisation than belonged to the other races by whom they were surrounded. Many carvings on stone, of a very remarkable character, the prevailing emblems being a serpent with a zigzag line passing through it, and two or sometimes three circles united by double parallel lines, are scattered over the whole of the tract which once formed the dominion of the Picts; but these curious monuments have not yet received the investigation they deserve, and whether they are Pictish or Norwegian remains doubtful. Of these various works an interesting account is given in Daniel Wilson's 'Archæology and Prehistoric Annals of Scotland,' 1851.

PICTURE. [PAINTING.]

PICTURESQUE (in Italian *Pittoresco*, painter-like or picture-like, and therefore expressed in German by the word *Mahlerisch*, which is of exactly the same import) is that quality which peculiarly recommends objects for pictorial representation. Consequently, in order to ascertain wherein this quality consists, it is necessary to consider what it is that, independently of other things, contributes to the general effect of a picture, and recommends more particularly certain classes of objects as suitable for the pencil. A picture is a representation upon a plane surface of bodies in relief, delineated as they appear to the eye, by means of form and colour, and their accompanying light and shade, which degree of relief or illusion will generally be in proportion as the objects themselves are favourable to artistical execution on account of the apparent diversity and variety which they present to the eye, and with which they must accordingly be represented in painting, although in themselves, or taken separately, they may appear monotonous. Hence, provided any object presents that variety to the eye which the artist requires in order to display the *artifice* of his pencil, it matters not how unpicturesque it may be when otherwise viewed, or though it should possess in itself none of those qualities which are commonly insisted upon as essential to the picturesque.

"The ideas of *neat* and *smooth*," says Gilpin, who is generally referred to as an authority upon this subject, "instead of being picturesque, *disqualify* the object in which they reside from any pretensions to picturesque beauty." But how can we reconcile this theory with fact when we observe that many things which are remarkable for the very *smoothness* here objected to as a disqualification, are selected by the artist as being admirably suited for his pencil? Still it may be granted that whilst the painter often has to *suggest* the idea of neatness or smoothness in the objects he depicts, he is careful to avoid that degree of neatness and smoothness which the artisan aims to produce. Smoothness is one quality of satin and velvet; and the idea of smoothness, it may be presumed, and generally of uniformity of colour also, throughout the material, is excited in the beholder; but then, in order to produce such appearance in painting, the artist must employ a great number of tints and colours, some of them quite different from the local or positive colour of the object itself, in order faithfully to express all the various modifications which the actual colour of the object receives from light, when seen as it is intended to be represented in the picture.

Another opinion, which appears equally incorrect, is that the picturesque is something distinct from and opposed to beauty, whereas this is very far from being the case; for although there is an extensive class of objects which are disagreeable in reality, and which yet become attractive in representation, where they are divested of all that renders them physically repulsive (such as beggars, hovels that seem the abode of penury and filth, &c.), there are likewise numerous others which, while they are beautiful in themselves, are far from being deficient in picturesque quality. It is true there are also not a few that are eminently delightful or beautiful in nature, yet become insipid in representation; but that is because they are deficient in that variety of colour and form which painting demands. A level well-kept lawn presenting a uniform surface of rich verdure is beautiful, that is, excites lively pleasurable emotions, but it is so far from picturesque that it is generally made use of as an argument to prove that neatness and smoothness are incompatible with picturesqueness. Such an object undoubtedly, when transferred to the canvas, and made to occupy a prominent place in the composition, does not produce a good effect, inasmuch as it then shows only as a monotonous surface of nearly unbroken green colour: but if we break its uniformity of surface by figures, by shadows, by gleams of light, by gradations of hue, and make it duly subordinate to the objects placed upon it, though it will still convey the idea of being a level piece of grass, it will be divested of its monotony, and may even become picturesque, if it should produce a good contrast to other parts.

The same theory holds true with respect to *form*, it being by no means correct that objects are picturesque in proportion as they are irregular and devoid of symmetry; though, as before said, the painter, whilst maintaining the appearance, gets rid of the formal presentation of symmetry. Thus, of a piece of regular architecture: if it be shown merely in elevation, a structure which is symmetrical will produce a stiff and inartistic appearance; but on the contrary, by means of judicious foreshortening or perspective, of shadows thrown upon it so as to break up the too great equality of its masses, and by means of figures and other accidents, it may be made to present an agreeable species of irregularity to the eye, at the same time that it suggests to the mind the idea of the most perfect symmetry.

Although, therefore, the term picturesque is often applied, by way of distinction, to that class of objects which are well suited for painting, but possess qualities more or less disagreeable in themselves, and so far implies something distinct from if not absolutely opposed to beauty, it comprehends also another class, which, while they are beautiful in themselves, require to be accommodated to pictorial representation, inasmuch as, in order to produce their images upon canvas, there must be great contrasts and irregularities, both in respect of form and colour. The truth probably is, that while every object may be, under certain circumstances, admissible into a picture, and by means of proper artistic treatment be so far rendered agreeable to the eye as to be then properly termed picturesque—yet there are particular objects which by their forms or surfaces are suitable for representation as leading features in a picture, without that artistic modification which more formal objects require, unless they be introduced as mere accessories: and hence these are not improperly distinguished by the term picturesque.

PIEPOWDER COURT. By the common law every owner of a fair or market is bound to hold a court for the decision of matters arising therein, which being instituted principally for the convenience of the itinerant dealer, was called in Norman French 'pied pouldreux,' the court of pipowders, "curia pedis pulverizati." The court is held before the owner of the fair or market, or his steward, who, by 17 Edward IV. c. 2, is prohibited from entertaining any action unless the plaintiff or his attorney swear that the cause of action arose within the precincts and during the time of the same fair or market. Before that statute these courts appear to have emulated those of Westminster Hall in seeking to extend their jurisdiction; and in the preceding reign, W. Larke, the servant of a burgess coming to the parliament, was arrested in the fair of the abbot of Westminster. He was transferred by his creditor, Margerie Janyns, to the Fleet, where he remained till, by the interference of the House of Commons, he obtained his discharge. (4 Rot. Parl., 357.)

This court in its turn has been gradually encroached upon by the superior courts, and is now fallen into total disuse. (See Blackst. 'Com.,' vol. iii., and Mr. Morley's account of Piepowder Court, vol. vii. of 'Notes and Queries,' new series, p. 498.) A book is deposited in Guildhall library, in the city of London, the last entry in which is, "September 2, 1854—The lord mayor not having proclaimed Bartholomew-fair, the court of piepowder consequently was not held."

PIER (from the French *pierre*, stone) the general name for the solid spaces between a series of openings in a wall, whether windows or arches; but in its technical meaning the term is more particularly applied to the pillar-like masses of masonry or brick-work from which arches spring, rising from what is termed the *impost* capping the pier, and which generally consists of a series of mouldings, although sometimes it is merely a platband, and occasionally the impost is omitted altogether, especially in rusticated basements.

Piers are frequently decorated with either pilasters or engaged columns. In many instances columns are substituted for piers, placed either singly or in pairs; and the arches spring either immediately from their capitals or from an entablature over them. There are again many examples in which both piers and a lesser order or sub-order of columns are employed, the latter being insulated on each side of the pier, and their entablature forming the impost from which the arches spring. Palladio's Basilica, or Palazzo di Ragione, at Vicenza, affords an example of the kind, in which the faces of the piers themselves consist of a larger order in half columns, so that the whole composition resembles a series of what are termed arched Venetian windows entirely filling up the spaces between the larger columns. Besides these and other modes of decoration, niches are occasionally introduced as ornaments to piers.

In Pointed Gothic architecture the insulated piers supporting what are distinguished by the name of pier-arches are not rectangular in plan, but splayed off or turned diagonally. Early English, or First Pointed piers, as at Salisbury, frequently consist of an insulated cylindrical column, surrounded by slender detached shafts, all uniting under the same capital; but sometimes the central column is octagonal or square. In Middle Pointed or Decorated churches the pier is frequently formed of four semi-cylindrical shafts united together; sometimes of eight shafts joined together, four large and four small, either plain or filleted up the face; in some cases it resembles a cluster of slender shafts united on a lozenge plan: but many varieties occur, though almost invariably the smaller shafts are attached instead of being detached as in the preceding style. The Third Pointed or Perpendicular piers are commonly in section a square or parallelogram with the angles splayed or cut in a deep hollow; or else they are often moulded shafts, which latter are sometimes a continuation of the mouldings forming the arch, carried down without any interruption by capitals or horizontal mouldings to the shafts, yet sometimes terminating below in moulded bases; at others *dying into* or uniting with the plain surface forming the footing or general base of the pier. [GOTHIC ARCHITECTURE.]

The term pier is also applied to the solid masses supporting the arches of a bridge; with the exception of the extreme ones, which are distinguished by the name of abutments. [ABUTMENTS.] The piers of bridges have no impost mouldings, and they are carried quite through the structure, their depth being equal to the breadth of the bridge itself from the parapet on one side to that on the other.

Pier is likewise the name given to a mole or jetty carried out into the sea. See the article PIERS.

PIERRIER was the term originally applied to an engine for casting stones; then to a small kind of cannon used with stone shot. It is now generally applied to a description of mortar for throwing stones, and also to a fougass [FOUGASS] loaded with stones made for the protection of breaches, &c., to be fired when the assaulting column approaches.

PIERS, *of Harbours and of Landing-Places.* In the artificial harbours formed upon the shores of bays or roadsteads, it is often necessary to execute a defensive mass of stone-work, or occasionally of timber, either for the purpose of securing the tranquillity of the harbour, or of providing the means for landing goods and passengers from ships which require a considerable depth of water. These works are known by the names of *piers* or of *jetties*, and their construction involves some of the most interesting questions of the science of marine hydraulic engineering, on account of the mechanical difficulties of their execution, and of the influence which every change in the outline of a sea-shore must exercise upon the relative conditions of the tides, currents, and alluvial deposits which take place on that shore. It would seem, from these remarks, that the most important points to be discussed in designing any work of these descriptions are—1, the directions to be given to them in plan; 2, the technical methods of their execution; and 3, the precautions to be taken to prevent, or the methods to be adopted for removing, any accumulation of alluvial matters caused by the erection of the piers.

1. Before entering upon the consideration of the details of piers or jetties, it may be observed that their execution is only desirable when the port they are intended to serve is situated in a bay which is naturally sheltered from the extreme violence of the sea. There are, no doubt, many harbours formed upon exposed coasts where the piers are made to inclose, at once from the sea, an outer harbour, leading to still water inner basins; as, for instance, at Ramsgate, Dieppe, &c. But

however the piers of such harbours may be placed, there must always be so great a danger of a ship missing the entrance in a storm, and the agitation of the waves in the outer harbour, at such periods, must produce such an amount of injury to the lock-gates of the inner harbour, that it may be laid down as a general rule that no safe harbour, no real harbour of refuge, can ever be formed on an open shore.

Assuming, however, that the position selected for the erection of the piers of a harbour is properly sheltered from the violence of the open sea, the direction of the piers themselves must be such as to allow the current of the flood-tide to assist in carrying a ship into the fair way of the channel; and the general practice appears to be in favour of their being placed so as to form an angle of from 12° to 20° to the direction of the prevailing winds, although local circumstances may, and often do, require that the latter law should be modified. If the sea should be exposed to the action of the wind to such an extent as to be very rough in stormy weather, the piers must not be built in straight, or even in long, circular, or elliptical lines; because in that case the agitation of the open sea would be transmitted to the inner harbour. But when the outlines of the piers, in plan, are made polygonal, the agitation of the sea may be reflected from side to side, and thus reach the inner harbour in perhaps a more dangerous manner than even in the case of the straight walls, because the waves will be more irregular, and will interfere greatly with the steering of the ship. It would appear that the system adopted in the construction of the jetties of Dieppe and of Havre, in both of which ports wooden breakwaters are inserted in the line of the piers (the latter being polygonal in plan), is the one most fitted for harbours in exposed situations; whereas, in sheltered positions, either straight or curved piers may be resorted to.

One of the most important functions piers are designed to perform being to facilitate the movements of the shipping resorting to a harbour, it is advisable in designing them to dispose their plans so as rather to facilitate the entry than the departure of vessels; because a ship in harbour can always wait for a favourable condition of circumstances, whilst a ship entering may be compelled to do so under stress of weather. Under these conditions, the entrances are disposed so as to allow the current of the flood-tide, or the inshore currents, if no marked tides should exist, to carry the ship into the fair-way channel, without exercising any influence likely to carry the ship against the jetty walls. As to the length to be given to the piers, it must be regulated, firstly, by the distance of the deep-water line from the line of the shore; secondly, by the set of the currents; and thirdly, by the means used in the particular port for hauling out the vessels. This latter practical detail of navigation will be found especially to affect the respective lengths of the piers, when two are used; because when the outgoing vessels are hauled by men, or warped by ropes, the pier which serves for those operations must be made sufficiently long to allow the vessel to make her first tack without any danger of her falling off against the opposite pier. As a general rule, it is preferable to make the pier under the prevailing wind longer than the other one; but local circumstances may at times render it necessary to modify the application of this law.

The width to be given to the channel between the two piers of harbours, where such double works are required, should be at least such as to allow three ships to enter at the same time, under full sail; and this width may vary between 100 and 250 feet, according to the class of vessels frequenting the harbour. At the heads of the piers the widths of the channels should be increased, because the ships entering require more room for their evolutions when under the influence of the way they bring in from the open sea than they do when they have followed the narrow channel for some time. The general use of steam-tugs, by enabling several vessels to leave at the same time, seems to have rendered it desirable to increase the width of the channels.

In river-piers, and in landing-stages, the only considerations which affect the plan to be given to the structures are, the depth of the water, and the possibility of the transmission of the agitation from the open sea, or of the local agitation produced by the action of the wind upon a large surface of water. The latter phenomenon, as is well known, depends on the depth quite as much as on the extent of the water-surface over which the wind blows; and it is for this reason that, in broad deep rivers, such as the Southampton Water, the piers are made curvilinear in plan, in order to inclose and protect a species of port; whilst on the shallow shores of the Thames, at such places as Southend, a straight pier is found to be sufficient for the real necessities of the locality. The peculiar range of the tides at any particular place may render it necessary to vary the means adopted for facilitating the loading and unloading of ships; but a study of the various landing-stages on the Thames will teach the student far more on this subject than it would be possible to do within the limits of this article.

2. As to the technical methods of constructing piers, they must evidently be regulated by the nature of the building materials furnished by the locality; and those structures may either be formed of wood, concrete, loose rubble stone, or solid masonry bedded in mortar; they may be either perfectly closed on the water-line, or open, so as to allow any littoral current to sweep through them.

When wood is used, the foundations intended to receive the upper structure require to be executed with great care, and in such a manner as to allow the said upper structure to be repaired with ease, and without affecting the foundations; for it is essential to bear in mind, that the shock, or the abrasion, produced either by vessels, by waves, or currents, and that the ravages of the *Teredo navalis*, or of the *Limnoria terebrans*, are most injurious to the parts of a wooden pier placed between high and low water-mark. All those parts must, therefore, be easily accessible, and renewable, either separately or entirely, as may be required. It is customary to execute wooden piers with piles and whaling-pieces, fixed below the level of the ground of the foreshore, and upon these a series of trapezoidal frames, carefully braced and bolted together, are placed. The lower part of these frames is covered with loose rubble, concrete, or fascines, in order to protect the foundations.

In open wood piers the frames are fixed at distances asunder of from 6 to 10 feet in the sea, according to the depth of water, and the habitual agitation of the latter at the place considered. The frames are made in the form of a trapezium, the inclined sides being respectively turned towards the open sea, or towards the sheltered channel, and forming an angle of from 13° to 33°, with a vertical line passing through their points of junction with the sill pieces. According to the width intended to be given to the roadway of the pier, the frames are made with one or more upright posts, between the inclined sides, and the whole are retained in their places by cross ties and raking braces converting the parts of the assemblage into a series of triangles, the sills and heads forming with the inclined sides the outer lines of the frames. Longitudinally these frames are connected by whales, stringers, and by the joists of the platform, and upon the latter the planking of the road-way of the pier is laid; this planking is formed of rather narrow timber, about 4 or 5 inches thick, laid with intervals of about 1¼ or 1 inch. The planks are spiked down upon the joists, but upon their ends they are clipped by a bridging joist, bolted to the longitudinal sill fastened to the frames; sometimes this bridging joist also bears a handrail of open timberwork. Tenon joints should be avoided in the carpenter's work of the frames, and under no circumstances whatever should the planking of the roadway be laid water-tight.

Should the wooden piers be filled in with rough stonework, the latter material will be retained by means of close boarding laid horizontally against the upright posts of the framing; and when that planking is carefully laid, the interior may be filled in with shingle, sand, or clay, or with concrete made with a hydraulic lime basis. It would appear that the best position for the planking, under these circumstances, is upon the outside of the frames; for although unquestionably, the planks would resist the tendency to displacement, from the weight of the filling-in material, more efficaciously if they were nailed upon the inside than if they were nailed upon the outside, yet in the latter case the framing would be far more efficaciously protected from the action of the waves, and it would be much easier to repair any accidental damage. The essential condition in all these cases is, in fact, that the substantial framing should be withdrawn as much as possible from the direct action of the sea; and that those parts, which are exposed to it, should be susceptible of being easily replaced.

The advantages of wooden jetties consist in the economy of their construction; but in practice it is found that the repairs of such work are so frequent, and so costly, that the use of wood should be only resorted to when it is utterly impossible to resort to the use of more durable, even though originally more expensive materials. Open wood piers have, however, another occasional advantage, namely, that they do not seriously interfere with the advance of any littoral current, and therefore they are not so likely to produce any change in the outline of the shore, by producing a deposit of alluvial matters, as a solid pier would do. In the landing stage lately erected at Margate an attempt has been made to unite the advantages of open piers with greater durability, by the use of cast iron piles; but it would be desirable to watch the effect of sea water on the iron during some years, before passing any opinion on the merits of this system. It may be added that the use of creasoted timber, for works exposed to the action of the sea, seems to have removed some of the most serious objections to the use of that material; for not only has this process increased the durability of the wood, but it would appear to constitute also an efficient protection against the teredo. Whether wood or iron piles be used, it is necessary to guard against the percussive action of the ground swell upon their heads; and it is for this purpose that the layer of concrete, rubble, or fascines, over the foundations is introduced.

Stone piers are either executed of loose rubble thrown down and allowed to assume its natural slope by the action of the waves; or of ashlar masonry external walls bonded together so as to form a series of cases filled in with concrete, or with rubble masonry, or with a hearting of earthwork protected by dressed masonry walls; the determining motives for the selection of either of these modes of execution being, of course, merely economical ones. The most difficult part of such structures consists in their foundations when executed at some distance from the shore, and in deep water, where caissons, or coffer dams cannot be used; especially if any strong littoral currents should exist in the particular locality. The very successful manner in which the new graving dock of Toulon was entirely constructed of concrete, under a head of water of not less than 37 feet, proves that it would be possible to make a much greater use of that material than is usually done in England; but of whatsoever material the piers may be formed, the necessity for protecting the foundations from the undermining actions of the currents, or of the ground swell, must remain the same. The other practical remarks to be made with respect to the execution of masonry piers are, that they must settle equably throughout their whole mass; that no openings should be left by means of which water could get into the interior, either directly, or by syphonment; that the masonry should be protected against the abrasion of the alluvions carried forward by the currents, and that the ships lying alongside the piers should not bear directly against the face of the masonry, for which purpose fender piles are used; finally, all abrupt projections must be avoided whether in the plan or the elevation of the piers, and the surface of the roadway must be carefully laid, so as to throw off all the water which may break over the piers. It is usual to make the width of the roadways, in the body of the work, from 10 to 28 feet, and to increase that width, at the heads, to from 30 to 50 feet; the body of the pier being kept about 10 feet above the level of high spring tides, and the heads about 12 feet above the same level. Generally speaking, a lighthouse is erected near the extremity of a pier; fog bells and signal guns are fixed; and the necessary bollards, or mooring posts, reeving pullies, capstans, and landing staircases are to be provided. It is curious that the softer calcareous stones are nearly as much affected by the boring mollusca as wood is affected by the limnoria and teredo; and that the solenidæ, pholidæ, and lithodomi, exercise fearful ravages upon that class of stones in some places. Where those animals abound, or where the littoral currents carry forward much alluvial matters, it becomes necessary to employ the more resisting siliceous rocks, or the granites.

3. The questions connected with the interferences likely to be produced by the erection of a pier upon the outline of a coast are often of extreme importance, not only to the harbour it is desired to create, but also to the whole of the surrounding district; and they must, therefore, be very carefully and attentively studied before such works are commenced. Unless there should exist some local cause of disturbance, it will, in fact, be found that the alluvial matters detached from cliffs and sea-shores by the action of the sea, will be carried forward by the flood-tide until they meet with some impediment able to check their advance; they then begin to accumulate behind this shelter until the angle is filled in, when the onward progress of the alluvions is resumed. If the littoral current should sweep across the mouth of the pass between the piers, it may carry the sand and shingle past the latter; but under almost all circumstances a large portion of the finer matters in suspension will be carried into and serve to silt up the harbour. The same thing will occur with a few trifling modifications when single solid piers are carried out from a shore, whether their plan be straight or curved, or whether they be constructed in the sea or in rivers; the alluvial matters will accumulate on the upside to the current, and it often happens (as it did lately at Dover) that, until the advance of the shingle again brings some light moveable materials to protect the fore-shore, the newly-created counter-current will wear away the original outline of the coast on the downside of the pier.

The Roman engineers appear at an early period in the history of engineering, to have recognised the importance of these laws, and they constructed their ports habitually upon a series of open arcades, with the avowed intention of interfering as little as possible with the advance of the littoral currents. In modern times the use of wooden or of iron open jetties has been recommended for the same purpose; but all these methods of palliating the evils of the interference with the progress of the alluvions are open to the serious objection that they leave the interior of the harbour without protection from the undulations of the open sea; and it therefore follows that if the commerce of the harbour should be important, the piers should be rendered sufficiently solid to intercept the normal deposition of the alluvions, even on the condition of constructing defence works for the shores on the down side. Any materials which, under these circumstances, may be carried round the heads of the piers must be removed, either by means of dredgers or by periodical sluicing. [SLUICE.] The practice of the most scientific engineers of the present day, it may be added, tends towards the use of dredgers in preference to sluicing; both on the score of economy and of efficiency. When the alluvial matters are removed by sluicing they are in fact only carried to the distance which the transporting power of the water can command; and then they almost always are thrown down in the form of a bar, across the mouth of the harbour. It would really appear that, under these circumstances, it is wiser to provide for the extraction of the alluvions by machinery, proportionate to the quantity brought in within certain definite periods; especially as it would then be easy to construct the piers in plan, solely with reference to the physical conditions of the locality as affecting the navigation, instead of (as in the case of resorting to sluicing) building the piers for the purpose of guiding the outpouring waters.

Lamblardie is the engineer who has studied the question of the advance of alluvial matters on a sea-shore with the most skill, attention, and success; and it is to his works, or to those of Zendrini, or of Sir H. Delabeche, that the student of this subject must be referred. The leading principles of this branch of the science of hydraulic engineering, so far as they are likely to affect the construction of piers or harbours, may, however, here be stated briefly as follows—allowance of course being made for local causes of disturbance.

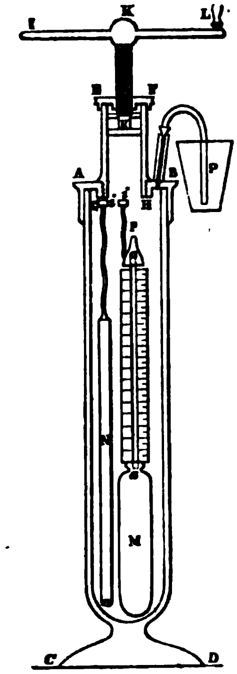
At the base of steep cliffs the alluvions follow the outlines of the coast, and they have, under ordinary circumstances, but little tendency to change their positions; in deep bays they will assume a curvilinear outline, whose concavity will be turned towards the sea in the direction of the prevailing wind, unless where modified by the line of the current. If the directions of the prevailing wind and of the current should be parallel to the shore, the transporting power of the current to carry forward alluvial matters will be less than when the direction of those forces assumes an angle of 45° to the coast; and when the wind blows perpendicularly to the shore, the waves may exercise a great effect in abrading the latter, but the movement of the alluvions will be almost imperceptible. A bay, or a harbour, whose axis may be in the line of the prevailing wind will, therefore, be exposed to become rapidly silted up; and this result will take place with increased rapidity if any land waters bringing down matters in suspension from the uplands should discharge themselves into the bay. One important remark to be made with respect to the deposition of alluvial matters in the embouchures of rivers receiving the flood-tide, under circumstances which should allow the latter to carry forward the shingle it previously detached, is, that the alluvions so carried in are of far more serious importance in their effects upon the accumulations around piers or harbours constructed in those rivers than are the alluvial matters brought down from the uplands. There is, in fact, every reason for believing that in such rivers as the Thames, the Seine, or the Rhine, more alluvial matter is carried in from the sea than the land floods can transport to their respective mouths; which, it may be added, is another reason for constructing open piers in such situations, because they offer less resistance to the natural laws of such localities. After all, engineering is essentially the science of adapting the means to the end desired; and economical conditions of first outlay may often render it expedient to depart from the strict application of even strictly demonstrated laws; but the attempt to run counter to those laws will always be productive of disastrous results; and in no case is this more true than with regard to the effect of piers upon the outline of a coast. The histories of Ramsgate, Dover, Calais, or Dunkirk harbours, or of the ports, so called, of refuge on our eastern coast may be referred to as illustrations of this remark.

The Brighton chain-pier may be referred to as an illustration of an ingenious method of constructing works of this description without producing any interference with the movement of the alluvions; but piers with such wide intervals between the points of support give no protection from the agitation of the waves.

PIETISTS, the name given in the 17th century to a kind of German Methodists or Evangelicals, who, being members of the Lutheran Church, were dissatisfied with the cold dogmatism of the generality of its clergy, and felt the want of a revival of religious feeling and of practical piety and charity. Without separating themselves from the church, they instituted meetings called "Collegia Pietatis," from which the denomination of Pietists was derived. Philip Jacob Spener, a divine of the Lutheran Church, who was preacher at Frankfort and afterwards at Dresden and Berlin, was the chief promoter of these meetings, which began about 1670. [SPENER, in BIOG. DIV.]

PIEZOMETER (πιέζω and μετρεω). Under ELASTICITY are noticed the various attempts to measure the compressibility of water and other fluids, and reference is made to Professor Oersted's instrument by which the problem was satisfactorily solved. It consists of a strong glass cylindrical vessel A B C D with a smaller cylinder A B E F screwed into the top, containing an air-tight piston K worked by a screw; M is a glass bottle, into the neck of which is ground a capillary tube *a a*, open at both ends, of fine bore, and each inch of its length must express a precise fraction of the contents of the bottle. This is done by weighing how much mercury the bottle will hold, and how much an inch of the bore of the tube. In some of Oersted's tubes each inch in length was found to hold $\frac{80}{1000000}$ths of the contents of the bottle. Let us now suppose the whole of the apparatus to be filled with water: any pressure upon it which causes its surface in the tube *a a* to descend one inch, will have compressed it by $\frac{80}{1000000}$ths of its bulk. The scale attached to the tube was graduated, each inch into 40 parts, so that a depression of the water in the tube through one of these divisions would indicate a compression of two-millionths. The apparatus being arranged as in the figure, only with the piston K at the bottom of the short cylinder in contact with the water which fills the large cylinder and the bottle M, the piston is screwed back towards E F, and as it recedes water is drawn into the vessel by the siphon B P from the vessel P. A cock is then closed in the siphon, and on screwing the piston downwards the pressure is propagated through the water in the cylinder, and also through the tube *a a* to the water in the bottle, such pressure being of course precisely the same within and without the bottle. A separation is made between the water in the tube *a a* and that in the large cylinder, by means of a bead of air contained in the glass cap P, which yielding to the pressure descends the tube *a a*, and serves as an index finger to the scale. The amount of pressure applied by driving down the piston is measured by means of the tube

N, which is closed at the top, open at the bottom, and graduated into equal parts. It has a ring of lead at the bottom to keep it immersed, and being full of air it readily indicates by its compression the amount of pressure applied to the water by the piston. By the law of Marriotte [ELASTICITY], the diminution in the bulk of aeriform bodies is proportional to the pressure, so that by observing the degree to which the air is compressed in the tube by the rise of water in it, the pressure exerted by the piston and that sustained by the water in the bottle is always known. In this way it was ascertained that water is compressed 46$\frac{1}{10}$th millionths of its bulk for every atmosphere of 15 lbs. on the square inch. Of course by filling the apparatus with some other liquid its compressibility could be ascertained, and taking mercury as unity in millionths of an inch, alcohol was found to be 20, sulphide of carbon 30, water 46·1, sulphuric ether 60.



The results obtained by Messrs. Colladon and Sturm differ considerably from those of Oersted. Those physicists state that a correction should be made for the compression of the substance of the tube and bottle, in consequence of the pressure sustained by them within and without. M. Poisson has given a simple rule for this correction, the necessity for which is denied by Oersted, who states that the recession of water in the capillary tube is about 1¼ millionths greater when bottles of lead and tin are used instead of bottles of glass. Piezometers with bulbs of different materials, filled with some liquid of known compressibility, have been used for ascertaining the cubic compressibility of the material of the bulbs. Thus it has been ascertained by Professor Forbes, that the cubic compressibility of caoutchouc is about the same as that of water, for when a piezometer with a caoutchouc bulb filled with water is compressed, the index remains nearly stationary in the stem.

PILASTER. [COLUMN.]

PILE. [GALVANISM.]

PILE. A piece of timber, or of iron (either cast or wrought), driven into the ground for the purpose of acting in the manner of a column, to transmit the weight of a superincumbent structure to an inferior resisting stratum, when the surface stratum is of so compressible a nature as to be unable to support the weight intended to be put upon it, and is so thick that it cannot be removed. Piles may be used either in water, or on land; and they may be used either isolatedly, or in close rows, retaining strictly the name of *piles*, in the first case, or those of *gauge piles*, *whole piling*, or *sheet piling*, in the latter. The gauge piles are those driven to mark out the position the close piling is intended to enclose; the whole piling is a close enclosure of whole baulks of timber; and the sheet piling is a similar enclosure formed of half baulks. When cast-iron piling is used, the gauge piles are made with grooves on the side, into which plates with stiffening ribs are inserted; whereas in the case of wood piling, the close piling is made, in the best description of works, with grooves and tongues, and is kept in its position by being driven between whaling pieces, or horizontal ties.

The descriptions of wood used for piles, in England at least, are beech, elm, larch, Baltic fir, rock elm, live oak, green heart, and the sabacu from Guiana. Of these woods the beech decays rapidly when exposed to alternations of dryness and of humidity, but it resists well when constantly immersed; elm resists changes of condition more successfully; and fir, when free from sap, is still more durable; the American hard woods, such as the rock elm and live oak, are preferable to the soft woods when the piles have to be driven into hard gravel, and they appear to be very durable; and it may be observed that the green heart and the sabacu have been used to a great extent on account of their supposed immunity from the attacks of the teredo. It is, however, now ascertained that those destructive creatures will attack the green heart with nearly as much readiness as they will attack any other kind of wood; and inasmuch as the lymexylon attacks the green heart on land, there can be little *à priori* reason for supposing that the limnoria should avoid it in the water. In fact, the result of all the enquiries or experiments which have been made with respect to the value of the processes for the preservation of piles, or to the unassisted resistance of woods in such positions, has hitherto been to show that nothing but the careful injection of creasote is able to prolong, even temporarily, their durability. As the boring worms, however, do not attack wood which is entirely buried in the ground; and as the durability of the wood itself is infinitely greater when it is protected from the action of external atmospheric influences by being buried; the common sense of the use of piling appears to be to carry the solid masonry or concrete foundations below the ground line, so as to ensure that the piles shall always be covered.

Wooden piles are generally pointed and shod with iron at the lower end, and they are temporarily hooped at the top, in order to prevent their heads from being split or beaten up during the operation of driving. Occasionally piles are driven with their broad ends downwards, when foundations are required to be executed in soft mud of indefinite thickness, as in the case of the port of L'Orient. It is considered that in such cases, the piles only act to resist compression by the friction developed upon their surfaces, and that their resistance is only equivalent to about 45 lbs. per foot superficial of those surfaces; but in addition to this small amount of resistance, piles, such as are thus described, are exposed to the great inconvenience of being likely to be deflected from the perpendicular by any subsequent compression of the subsoil. If, however, such a mode of driving piles be resorted to, and indeed in almost all cases of piled foundations, it is advisable to commence with the outer rows, and to drive inwards, or towards the centre of the mass, in order to compress the enclosed ground as much as possible under the seat of the intended foundations. Of late years, the introduction of the Mitchell's screw piles has greatly facilitated the execution of works of this description, in homogeneous and soft foundations; but they do not act in any way to compress the ground, and are of more use for the purpose of fixing piles intended to resist lateral strains, than for driving piles intended to resist vertical weights.

In calculating the weight a pile should support, it is not customary to take into account the assistance it receives laterally from the ground into which it is driven; and the number of piles, and the load to be brought upon them are ascertained upon the supposition that they must be able to support that load if they were really isolated; or in other words, the longer the pile the less must be the weight it is made to bear. Rondelet, in his 'Art de Batir,' gives a series of tables of the respective weights which may safely be brought upon piles of variable ratios between the diameters and height; and it may suffice here to say, that when that ratio does not exceed 16 times the diameter, Rondelet considered that the load brought upon the pile *permanently*, might safely be carried to between 430 and 500 lbs. per inch superficial of the sectional area. Morin, after verifying Mr. Eaton Hodgkinson's tables of the resistance of columns to compression, increased the value of the resistance of piles; and the proportionate (permanent safety) loads to be brought upon them are considered at the present day to be nearly as follows:—

Ratio diameter . .	12	14	16	18	20	22	24	32	36	40
Weight in lbs., per inch superficial	629	596	559	525	496	464	426	312	271	218

When piles are being driven, they should be made to advance so far into the earth that the effort exercised upon their heads, or the driving weight, should virtually exceed the statical effect of the intended permanent load; and when this is attained, the pile is said to have attained *its refusal*. There are no recorded experiments upon which to found a theory for ascertaining the conditions regulating the descent of piles; and therefore, the rules for fixing their refusal must be considered as being simply empirical. It is, however, customary to consider that a pile has attained a satisfactory refusal, if it be intended to support 25 tons, and will not descend more than ⅜ths of an inch, under a series of 30 blows from the monkey of a ringing engine, weighing 12 cwt., and falling a distance of 4 feet; or under a series of 10 blows from a monkey of the same weight falling a distance of 12 feet; if the weight be reduced to 12½ tons per pile, the refusal is diminished to ⅝ths of an inch; and if to 5 tons, to 2 inches. At the bridge of Neuilly, where the piles support a weight of 52 tons each, Perronet adopted a refusal of 1-5th of an inch for a series of 25 blows with a 12 cwt. monkey falling 4 feet 8 inches. It is important to observe, in all these cases, that the piles may often appear "to refuse," after having been struck by frequent blows succeeding one another rapidly, perhaps on account of the superinduction of a state of vibration in either the piles themselves, or in the ground; and that if the driving be recommenced, after an interval long enough to allow the vibration to cease, the pile will begin to descend again. In practice, therefore, no pile should be considered to have attained its refusal, until the trial has been repeated at the interval of at least one day after the first observation upon its conditions of descent.

In regularly piled foundations, it is now the custom to surround the heads of the piles with concrete, to a depth of three feet below the timber platform, and to extend the concrete at least three feet beyond the outer line of the piles. The platform is usually made of two courses of planks, the lower one tenonting upon the pile-heads, and the upper one halving upon the lower. The whole of this timber is again buried in concrete to a depth of two feet above its uppermost surface. It is sought, in cases where these precautions are taken, to render the whole of the foundation homogeneous, and to guard against any lateral displacement by the piles turning over on their lower external edges, an accident which often occurs when a lofty quay wall is built upon a compressible subsoil; and although the precautions may be costly, the result of the works executed in many of our own, and in many foreign, sea-ports, proves that they cannot safely be dispensed with.

PILE-ENGINE. The machinery used for the purpose of driving piles is rather varied; but it is only within a very few years that it has assumed anything like a scientific character, or has admitted the application of any mechanical power other than mere brute strength.

The pile-engines which are still used in countries behind the spirit of the age in the development of the mechanical arts, such as Holland, Germany, Spain, or Italy, are the old-fashioned ringing engine, in which a monkey, or a large hammer, is raised by means of a pulley and a rope, the latter being connected with a great number of cords, which are pulled in unison by an equal number of men. The weight of the monkey of these machines is usually about 10 or 12 cwt., and the fall is only from 4 feet to 4 feet 8 inches; and in practice it is found that the dynamical force, thus brought to bear upon the piles, is not sufficient to drive them through grounds of any notable degree of resistance; the ringing engines, moreover, require so much space, and so great a number of men, as to render their use extremely inconvenient when numerous piles have to be driven in a small area.

In England and in France the pile-engines generally used consist of a vertical frame of about 24 feet, or at times 30 feet, in height, bearing at the top a pulley, over which passes a chain starting from a crab fixed on the ground, and able to reach a monkey resting, when the machinery is in repose, on the pile head. When the pile is being driven the monkey is raised until some fixed pins open the clutch which supports the monkey, and the latter then falls on the pile head; the usual weight of the monkey is from 12 to 16 cwt., and the fall varies from 12 to 18 feet, according to the resistance the pile meets with in its descent; occasionally the fall may be extended to 26 feet, and the crabs are often worked by steam, when the number of piles to be driven within a given area is considerable. The principal objection to the use of these engines consists in the danger which must exist of their splitting the piles, either by turning the shoe, or by the development of cross fissures, from the enormous force of the blow produced by a great weight falling from a great height; but at the same time the rate of advance they produce is very rapid, and they are economically worked.

The various systems for sinking piles by pneumatic pressure have not hitherto succeeded well, when applied to piles of the dimensions ordinarily used, although their results have been satisfactory when large cylinders have been used. At the present day these systems have been almost entirely abandoned; and when it is necessary to sink even large hollow cylinders, to a very great depth through light soil, the use of caissons working with compressed air, in the same manner as was done at the Rochester or the Saltash bridges, has been substituted for the costly and partially inefficient methods of pile driving by pneumatic pressure. In fact, the latter system consists in creating a vacuum beneath a surface exposed to the air, and the weight of the atmosphere in excess of the weight of the enclosed air is supposed to cause the pile to descend; but it frequently happens, that in proportion as the internal air is withdrawn, so does the moveable ground beneath it follow into the open space; and by thus compressing the air in the interior it annihilates the difference between the two pressures. Whereas, when the compressed air is used, a fresh quantity is pumped into the interior of the cylinders until it attains a pressure of about 60 lbs. on the square inch, which is sufficient to prevent any running sand, or semifluid mud, from rising under ordinary hydrostatic pressure at least. But it must be repeated that either of these systems is adapted to sinking caissons rather than piles, although they might originally have been applied to the latter.

The Mitchell's *screw-piles* are so called, because they are made with the worm of a screw at their extremity, and they are driven by turning them in the ground in precisely the same manner as an ordinary screw is driven into wood. It must, however, be evident, that piles so driven do not compress the ground in any appreciable manner; and that they do not furnish any direct evidence of the amount of resistance they offer to vertical compression. The Mitchell's piles are admirably adapted to resist efforts of tension, as in the case of the dead works of a floating buoy, or of a hauling lump, or mooring block; because the whole prism of earth around the screw must be torn out before they can move, and the same condition renders them equally fitted for the piles of piers driven into tolerably firm and even soils, which piers are exposed to cross seas, but are not exposed to heavy vertical weights. The easy descent of the Mitchell's piles, and the absence of vibration whilst they are descending, may, in many practical instances, constitute a great recommendation for them.

The most striking illustration of the adaptation of machinery to pile driving, is perhaps the application of the Nasmyth's steam hammer to this purpose. In this case the steam is admitted into the bottom of a cylinder bearing a piston-rod connected directly with the monkey, so as to raise it vertically until the piston reaches the head of the stroke; the steam then escapes, and the piston falls. The weight of the monkey in these engines need only be limited by the capacity of the cylinder, or by the elasticity of the steam; and it is in practice made to range between 32 and 45 cwt.; but the height of the fall is limited by the length of the stroke, and it rarely exceeds 2 feet 6 inches. In the ordinary pile engines, the number of blows does not exceed 35 or 40 per hour; but with the Nasmyth's hammer it is easy to increase that number to between 50 or 60 per minute. It follows from the dynamical conditions of this engine, that in ordinary clays, sands, or alluvial deposits, where the resistance to the descent of the piles is not very great, and is tolerably uniform, that the Nasmyth's pile-engine drives piles with a rapidity far greater than any other machine hitherto applied to such a purpose; but when the resistance becomes considerable, the piles are very much exposed to be beaten up, to be set on fire, or to be broken by the frequent blows; or if those results should not occur, they may be set into such a state of vibration as to oppose a serious resistance to their descent. The writer of this article has actually seen 5880 blows struck in 1¾ hour upon a 14 square pile, by a monkey of 42 cwt. falling 2 feet 6 inches, without causing it to advance more than 8 inches; but the head of the pile was literally beaten up into a sponge: an ordinary pile-engine with a monkey of 16 cwt. falling 18 feet, would, in six hours, have produced a greater dynamical effect under far more advantageous conditions. The use of the Nasmyth's steam pile-driver should therefore be limited to the class of soils above-named; but in driving through hard gravel, or tufaceous limestone, the monkeys with large falls and slower action should be used: in fact, the mechanical effect produced by a weight falling on the head of a pile is such that the descent of the pile is proportional to the fall of the monkey; and it is admitted that economically there is an advantage in the adoption of heavy monkeys falling through heights ranging between 12 and 20 feet. It has been shown, by direct experiment, that the descent of a pile is proportional to the mass of the monkey, added to that of the pile, multiplied by the square of the common velocity of those two bodies after the shock. For if the mass of the monkey be represented by m, and that of the pile by m', the common velocity of the monkey and of the pile by u, and the velocity of the monkey before the shock by V, the descent may be derived from the following formula:—

$$(m+m')u^2=(m+m')\frac{m^2V^2}{(m+m')^2}=\frac{m^2V^2}{(m+m')}$$

but as in this case $V^2=2gh$, in which $g=$ the accelerating force of gravity (32⅙ feet in London), and $h=$ the fall of the monkey, the descent of the pile is proportional to $\frac{2gm^2h}{m+m'}=\frac{2gmh}{1+m'}$.

The nature of the soil to be traversed, and the number of piles to be driven in a given time, must be the determining motives for the selection of the pile-driving machinery to be adopted. For camp-sheeting the ringing engine will suffice; the Nasmyth's hammer is admirably adapted to soft, equable, soils; but the ordinary pile-engine worked by crabs is the best fitted for hard irregular soils.

PILES. [VEINS, DISEASES OF THE.]

PILGRIM is the name given to a person who travels for the purpose of visiting the shrines or tombs of holy men, or places which from any cause have come to be regarded as sacred; and the act itself is called Pilgrimage. The words pilgrim in English, *pilger* in German, *pellegrino* in Italian, *pélerin* in French, are all corruptions of the Latin "peregrinus," which means a stranger or foreigner. Pilgrimages to Jerusalem, Bethlehem, and other places which were the scenes of the Saviour's life and death, and which are included in the general name of the "Holy Land," began at an early period, probably about the time of Constantine. We are told by Eusebius and others that Helena, Constantine's mother, proceeded on a pilgrimage to Palestine, and built the church of the Holy Sepulchre. The practice became common about the end of the 4th century, and we find it noticed as such by the fathers of the church, Jerome, Augustine, and others. Gregory of Nyssa, in one of his epistles, reproves the indiscriminate custom of pilgrimages, especially by women, who, he observes, were particularly exposed during a long and toilsome journey through countries like Syria, notorious for licentiousness of manners. His opinions concerning pilgrimages are in accordance with those expressed by other fathers of the church. St. Augustine, St. Chrysostom, and St. Jerome, all agree as to the uselessness of such pilgrimages.

In the course of time, however, the practice of pilgrimage increased, and extended to other places besides Palestine. People resorted to the shrines of St. Peter and St. Paul at Rome, to that of St. Iago de Compostella in Spain, of St. Gregory of Tours in France, to the monastery of Einsiedlen in Switzerland, to our Lady of Loreto in Italy, to the tomb of Thomas à Becket at Canterbury, and to many other places.

The pilgrim's garb was a gray or brown gown, a broad-brimmed hat adorned with a palm leaf if going to the Holy Land, or a scallop-shell if going to other places, with a long staff round at one end and pointed at the other; and his pouch was a hollowed gourd.

In the west, the celebration of the Jubilee perpetuated the custom of pilgrimages to Rome. The institution of the Roman Jubilee is due to Boniface VIII. At the beginning of the year 1300, a report was spread at Rome that all those who should visit the church of St. Peter that year would obtain a plenary indulgence, and that every centenary year enjoyed the same privilege. Pope Boniface searched the ancient records for the grounds of this report, and he interrogated a man 107 years old, who told him that in the year 1200 his father, a labouring man, had gone to Rome to get the indulgence, and had advised him, if he should live to the next centenary, to follow his example. Some other old men in France and Italy confirmed this tradition. After consulting the College of Cardinals, Boniface issued a bull, stating that "as according to the faithful report of the elders great indulgences are granted to those who visit the church of the prince of the Apostles every hundredth year, we confirm them, and grant plenary indulgence to all those who have confessed, and, being duly repentant, shall visit the churches of the Apostles during the present year, 1300, and every other centenary year after." This is the origin of the festival which was afterwards called jubilee. Fifty years later, Clement VI. reduced the period of its recurrence to half a century, and styled it jubilee in commemoration of the jubilee of the Jews, which was celebrated every forty-ninth or fiftieth year, when all slaves became free, and all lands returned to their original owners. (Leviticus, xxv. 10, *et seq.*) This jubilee began at Christmas, 1349, and it was attended by a prodigious concourse of people from all parts of Europe, it is said, more than a million at a time. Petrarca, who went to Rome on that occasion, speaks with wonder of the concourse of pilgrims. The crowd diminished during the heat of the summer, but increased again towards the fall of the year 1350, at which time the nobility, and especially the great ladies, from distant parts came. It appears that all these ladies came by the road of the March of Ancona, where Bernardino da Polenta, lord of Ravenna, one of those robber barons of the middle ages, and his men, lay in wait for them, and ravished some of them, and obliged the rest to pay ransom. The chronicler who relates this adds, that "had they remained at home, such mishaps would not have happened to them;" and that "indulgences and pilgrimages are not suited to young ladies." (P. Azar, *Chronica*, fol. 359.) Similar misfortunes are reported to have befallen those ladies who in former ages resorted to Palestine, when pilgrims were exposed to insults and even violence.

The period of the recurrence of the Jubilee has been altered several times; some popes reduced it to twenty-five years, in order that each generation should have the advantage of it. There are foundations at Rome for receiving and feeding the poorer class of pilgrims who resort there at jubilee time; one of these institutions or hospitals is called la Trinità dei Pellegrini. The fashion of devotional pilgrimage however has very much decreased in our time; but yet there are annual "excursion" pilgrimages to the Holy Land from France, &c. The popes granted to several monasteries the privilege of holding jubilee, with the indulgences attached to it, every fifty years; among others to that of Canterbury. Concerning former pilgrimages, many notices are found in the ancient chroniclers, especially those of the Crusades. Chaucer, in his 'Canterbury Tales,' has given sketches of the pilgrimage to Thomas à Becket's shrine. Erasmus wrote a 'Pilgrimage to Walsingham and Canterbury,' republished in 1849, edited by J. G. Nichols. Henry Watson wrote 'Instructions for Pilgrims to the Holy Land.' Timberlake wrote the 'Travels of Two English Pilgrims to Jerusalem, Gaza,' &c.

The Mohammedans have also their pilgrimages. According to a precept of the Koran, every Mussulman who possibly can, ought once in his life to visit the tomb of the prophet at Mecca and the Holy Kaaba. [MOHAMMED, in BIOG. DIV.] The ceremonies performed by the pilgrims at Mecca are minutely described by Major Burton in his 'Pilgrimage to El Medinah and Mecca.' There are also sanctuaries for the Mohammedans of the sect of Ali at Mushed in Khorassan, and Koom in Irak Ajemi, which contains the tomb of Fatima, the sister of Iman Reza, which are visited yearly by numbers of Persian pilgrims.

The Hindus likewise have their places of pilgrimage, the most celebrated of which is that of Juggernaut or Jagathnatha, on the coast of Orissa in Coromandel, where extensive buildings are allotted for the idol and his priests. The statue of the idol is brought forth at certain periods, and mounted upon an enormous car sixty feet high, which is dragged along by the devout multitude amidst crowds of pilgrims, who resort thither from every part of Hindustan. The procession is attended by dancing girls and dissolute young men, who perform acts of obscenity, while, until the practice was discountenanced by the English authorities, fanatics threw themselves under the wheels of the car to be crushed to death. The whole scene, of which Buchanan, Laurie, and other writers give a full account, is a frightful compound of superstition, cruelty, and lust.

The Japanese are said to have their pilgrimages to the temples of Xinto or Xaca, of which accounts are given by Thunberg and other travellers.

PILING OF SHOT, an instance in which a process of pure mathematics, the summation of series, becomes of immediate application. Three shot, or spherical balls of equal size, placed together on the ground, will support a fourth, and four will support a fifth. Not more than four can be placed together so as to touch each other and support one more. Hence arise two distinct methods of piling shot, the triangular and the rectangular.

In a triangular pile the base is an equilateral triangle, with one shot at the vertex, two adjoining, three in the next row, and so on. The number of shot in the base (supposed to have n rows) is therefore $1+2+3+\dots+n$, or $\frac{1}{2}n(n+1)$. The number of interstices in which other shot can lie is $1+2+3+\dots+n-1$, or $\frac{1}{2}(n-1).n$. If such a pile be completed until one shot stands at the vertex, the pile will be n layers high, and counting from the top, the layers will severally contain $1, 3, 6, 10, \dots \frac{1}{2}n(n+1)$, of which the sum

$$\frac{n(n+1)(n+2)}{6}$$

is the number in a complete triangular pile.

Let there be a rectangular base, say of 16 by 11. The number of interstices is 15 by 10, and when the second layer is put on, the number of interstices is 14 by 9, and so on; whence the eleventh layer is a single row of 6. If a and $a+b$ be the numbers in the longer and shorter sides of the rectangular base, the number in the complete pile is

$$\frac{a(a+1)(2a+1+3b)}{6}$$

If the base be a square, $b=0$, and the number in the pile is

$$\frac{a(a+1)(2a+1)}{6}$$

PILLAR. [COLUMN.]

PILLORY. The pillory was a mode of punishment for crimes by a public exposure of the offender, used for many centuries in most of the countries of Europe under various names. In France it was called *pillorie*, and, in more recent times, *carcan*; and in Germany *pranger*. In England it existed before the Norman conquest, and was in frequent use in our criminal law from that period until it was finally abolished in the year 1837, by the statute 1 Vict., c. 23. In the laws of Canute (Wilkins's 'Anglo-Saxon Laws,' p. 11) it was called *healfange*, or, more correctly perhaps, *halsfang*, that is, catch-neck, a name derived, without doubt, from the form of the instrument used, and the mode in which the punishment was inflicted. Hence also the Latin name of the pillory, *collistrigium* (quasi collum stringens), is said to be taken. (Cowell's 'Interpreter,' ad. voc. 'Pillory.') The tumbrel, *trebuchetum*, an obscure punishment, which is said to be the same as the ducking or cucking stool, and was used for women, who were exempted, on account of their sex, from the pillory, is often spoken of in the ancient English laws in conjunction with the pillory. In early periods of English history, the right of having a pillory and tumbrel, and sometimes also *furcæ*, or gallows, within their jurisdiction, was claimed and insisted on as a beneficial franchise by lords of leets: in process of time this privilege was converted into a burden for the public use; and such persons were held to be bound to maintain a pillory and tumbrel as appurtenant to their criminal jurisdiction, on pain of forfeiture of their franchises. (Hawkins's 'Pleas of the Crown,' book ii., cap. 11, sec. 5.) In like manner the 'Droits de Carcan et de Pillori' are mentioned in ancient French customaries as belonging formerly to seigneurs haut-justiciers. (Vouglans, 'Loix Criminelles de France.')

The form of the pillory as used in England in the time of Henry VII., may be seen in a collection of prints published by the Society of Antiquaries. In modern times it was nothing more than a wooden frame or screen, raised several feet from the ground, and behind which the culprit stood, supported upon a platform, his head and arms being thrust through holes in the screen, so as to be exposed in front of it; and in this position he remained for a definite time, sometimes fixed by law, but usually assigned at the discretion of the judge who passed the sentence.

The pillory was intended "magis ad ludibrium et infamiam quam ad pœnam;" but serious injury, and, in some cases, loss of life, has occurred where the populace have been much excited against the offender. (Barrington's 'Antient Statutes.') On the other hand, where the unpopularity of the prosecution or other causes have occasioned a feeling in the public mind favourable to the offender, the execution has sometimes been a species of triumph.

In England the pillory was abolished by the statute above referred to; in France, the carcan was discontinued upon the revision of the Code Pénal in 1832; and in the numerous codes and schemes of codes which have appeared in the different states of Germany during recent years, punishments by public exposure of the person or otherwise tending generally to degrade the character have been omitted. ('Entwürfe für Würtemberg, Sachsen, Hannover, Baden,' &c.)

PILOT. In many maritime countries the name of pilot is applied to a constant officer in a ship, who has the charge of the helm and the general direction of the ship's course; and also to a person who undertakes the special charge of navigating ships in particular rivers, roads, or channels, or in entering and leaving ports, and who is entrusted with such charge independently of the captains or masters, in consequence of his peculiar acquaintance with the navigation within the limits to which his duty is restricted. In France large vessels usually carry several officers of the former kind, who are called *pilotes hauturiers*; the latter description of pilot is called *pilote côtier*, or *lamaneur*. The ancient laws of France contained provisions for the education and regulation of both these kinds of pilots (Merlin, 'Répertoire de Jurisprudence,' art. 'Lamaneur et Pilote;' Valin, 'Commentaire sur l'Ordonnance de la Maine du Moi d'Août,' 1681, tom. i., p. 483); but they are not mentioned in the Code de Commerce. In England the term is applied exclusively to officers of the latter description. By the laws of many maritime countries, taking a pilot to navigate a vessel on approaching port has been considered from early times to be obligatory on the master. Thus, by the laws of Wisbuy, which were promulgated in the 12th century, and were incorporated in the marine laws of most European countries, it was compulsory on the master to take a coast-pilot on board, though the merchant or master opposed it. ('Ordonnances de Wisbuy,' art. 44.) A similar provision is found in the 'Consolato del Mare.' (Boucher, 'Consulat de la Mer,' vol. ii.)

In this country, pilots are established at several ports for limited parts of the coast, who are appointed and regulated sometimes by acts of parliament, and sometimes by charters of incorporation; and in general the master of a ship engaged in foreign trade must put his ship under the charge of such a pilot, both in his outward and homeward voyage, within the limits of every such establishment. Pilotage in the Thames and Medway, and along the coast, from Orfordness to the Isle of Wight, excepting the jurisdiction of the Cinque Ports, has been for several centuries under the management of the corporation of the Trinity-house, and acts of parliament have been from time to time passed to regulate the Trinity-house and Cinque Port pilots. All these regulations were reconsidered by parliament in the year 1825, and the majority of them were consolidated in the statute 6 Geo. IV., c. 125, which contains also some general provisions respecting pilots in other parts of the kingdom., (Abbott 'On Shipping,' 1840.)

It was not till the passing of the Merchant Shipping Act, in August, 1854, that the present system of pilotage was organised. By it the existing powers for regulating pilotage were confirmed and arranged. Rules of pilotage, limits of districts, funds for superannuated pilots, the granting, renewing, and cancelling licence certificates, powers to make and amend by-laws—all these underwent revision: the Trinity-house being the source of authority in case of irregularities in the furnishing of returns, &c.; the whole being subject to the Board of Trade (*vide* 17 & 18 Vict., c. 104).

PIMARIC ACID. [Turpentine.]

PIMELIC ACID ($C_{14}H_{10}O_6\,2HO$). A white crystalline acid, obtained by the action of nitric acid upon oleic acid, bees'-wax, spermaceti, linseed oil, and other fatty bodies. It is a bibasic acid, and its neutral salts have the formula $C_{14}H_{10}O_6\,2,MO$.

PIMENTA, or PIMENTO, allspice, the produce of *Eugenia Pimenta*, a tree native of the West Indies, but cultivated almost exclusively in Jamaica, thence called Jamaica pepper. The unripe two-seeded berries, which are about the size of a pea, are dried by frequent turning in the sun, by which their colour is changed from green to brown or grayish-brown. Externally they are of a dull appearance, somewhat rough, crowned with the remains of the calyx, and frequently furnished with a little stalk. The shell is very brittle, about the thickness of a card, and encloses two seeds, which are roundish, dark brown, and somewhat shining; and having a weak aromatic taste. The shell possesses an agreeable clove-like taste and smell. Two kinds are met with in commerce, English and Spanish, of which the former is the better.

Pimento berries are said to be adulterated with the berries or seeds of the Cocculus Indicus; these are larger, about the size of bay berries, extremely bitter, and, in large quantity, poisonous. This adulteration is scarcely credible, for the latter come from the East Indies, are dearer, and could only be successfully passed off when mixed with the powdered berries of pimento. The fraud may be detected by making an infusion, which, if pure, is not disturbed by tincture of galls or acetate of lime, which cause a precipitate when cocculus berries are present.

The shell appears to be the most efficient part, and to contain more of the active principles.

Bonastre obtained from the shells 10 per cent. of a heavy volatile oil, 8 per cent. of a green fat oil, an extractive containing tannin, resin, gum, and sugar; also a principle similar to caryophyllin.

By distillation an oil is procured which resembles oil of cloves, and which conducts itself in the same way towards alkalies. It is a mixture of a light and heavy oil.

As an aromatic stimulant, pimento stands intermediate between pepper and cloves, for the last of which, on account of its greater cheapness, it may often be substituted.

It is useful in dyspepsia dependent upon atony of the stomach, and in diarrhœa dependent upon a similar cause.

PIN MANUFACTURE. It is not known at what time pins made of metal of the present form were first manufactured in this country, but it must have been some time previous to 1543. In this year a statute was passed (35 Henry VIII., c. 6), intituled "An Acte for the True Making of Pynnes," in which, after stating that much deceit had been practised in the making of pins, it was enacted that in future none should be sold but such as were well pointed and had the heads firmly soldered on to the stems, and further that the price charged should not be more than six shillings and eight pence a thousand. No mention is made of them in any previous statute, with the exception of an act of Richard III., which prohibited their importation from abroad; but the pins there alluded to were much larger than those now in use, and were made of box-wood, bone, or silver.

Pins of English manufacture being in great repute abroad, the foreign trade is very considerable. The number actually made in this country daily was estimated thirty years ago at fifteen millions; but it must now be far greater, although there exist no means of determining it. By hand labour ten persons can produce a pound, or about 5500 pins of medium size, in rather less than eight hours: each person taking up the work as soon as the operation preceding that which he or she has to perform is completed, and each being employed about a tenth part of the eight hours. These calculations, relating to the division of labour, are taken from Babbage's 'Essay on the General Principles which regulate the application of Machinery,' in the portion of the 'Encyclopædia Metropolitana,' comprising Manufactures and Machinery; they are valuable in relation to the division of labour, but the statistics or quantities are no longer strictly applicable to the manufacture under notice.

The first thing to be done, in the pin-manufacture, is to reduce a quantity of brass wire to the requisite size. This, though properly speaking a preliminary operation, is generally done in the pin-factory, as the wire is received of larger diameter than necessary. It is performed in the usual manner of wire-drawing. The wire is then made up into coils of six inches diameter; and any dirt or crust which may be attached to the surface is got rid of by first soaking the coils in a diluted solution of sulphuric acid and water, and then beating them on stones. The next process is to straighten the wire. Two short lines, parallel and very close to each other, are drawn at one end of a board or table, and seven or nine pins are driven into the wood, at a short distance apart, alternately in the two lines. The end of the wire is placed between these two rows of pins and is thus held in a zig-zag position: it is then drawn between the pins to the other end of the table, and a length of about twenty feet is cut off. This process is repeated until all the wire is straightened and cut into similar pieces. A number of these lengths are then taken together, and by means of a powerful pair of shears, worked by the foot, they are cut up into shorter pieces, each a little longer than six pins. These latter pieces are then pointed at each end. The pointer sits in front of a small machine, which has two steel wheels or mills turning rapidly. These wheels are usually about six inches in diameter, and their rims or cutting surfaces are about three inches broad. The rims are cut somewhat after the manner of a file: one coarse, for the rough formation of the points, and the other fine, for finishing them. Several of the pieces of prepared wire are taken in the hand, and by a dexterous movement of the thumb and fore-finger are kept continually presenting a different face to the mill, against which they are pressed. The points are then finished off by being applied in the same manner to the fine mill. After both ends of the pieces have been pointed, one pin's length is cut off from each end, when they are repointed; and so on until each length is converted into six pointed pieces. The stems of the pins are then complete. The next step is to form the head, which is effected by a piece of wire called the mould, the same size is that used for the stems, being attached to a small axis or lathe. At the end of the wire nearest the axis is a hole, in which is placed the end of a smaller wire, which is to form the heading. While the mould wire is turned round by one hand, the head wire is guided by the other, until it is wound in a spiral coil along the entire length of the former. It is then cut off close to the hold where it was commenced, and the coil taken off the mould. When a quantity of these coils are prepared, a workman takes a dozen or more of them at a time in his left hand, while with a pair of shears in his right he cuts them up into pieces of two turns or spirals each. To prevent them from flying off from the shears when separated, the fore-finger of the left hand is applied to the tip of the coil, and the end thus cut off is caught in a bowl placed beneath it. In some factories this is performed by a chisel and gage, instead of the shears, a mode which has the advantage of requiring less dexterity. The heads, when cut off, are annealed by being made hot and then thrown into water. When annealed, they are ready to be fixed on the stems. In order to do this, the operator is provided with a small steel die, containing a hollow the exact shape of half the head. Above this die, and attached to a lever, is the corresponding die for the other half of the head, which, when at rest, remains suspended about two inches above the lower one. The workman takes one of the stems between his fingers, and dipping the pointed end into a bowl containing a number of the heads, catches one upon it and slides it to the other end; he then places it in the lower die, and, moving a treadle, brings down the upper one four or five times upon the head, which fastens it upon the stem, and also gives it the required figure. There is a small channel leading from the outside to the centre of the dies, to allow room for the stem. The pins are now finished as regards shape, and it only remains to tin or whiten them. They are boiled in a pickle, either a solution of sulphuric acid or tartar, to remove any dirt or grease, and also to produce a slight roughness upon their surfaces, which facilitates the adhesion of the tin. After being boiled for half an hour, they are washed, and then placed in a copper vessel with a quantity of grain tin and a solution of tartar; in about two hours and a half they are taken out, and after being separated from the undissolved tin by sifting, are again washed. They are then dried by being well shaken in a bag with a quantity of bran, which is afterwards separated by shaking them up and down in open wooden trays, when the bran flies off and leaves the pins perfectly dry and clean.

Papering the pins for sale is one of the slowest operations in the manufacture. When the pins are separated from the bran, as just described, they are thrown into bowls, with their points in all directions; but before papering it is necessary to arrange them all the same way. This is done by laying a number of them upon a sort of comb, between the teeth of which they are caught by the head; they are then placed upon a piece of metal, with as many grooves as there are pins required in a row, and held there by another piece of metal being placed upon them. These pieces of metal are not quite so broad as the pins are long, so that their points project beyond the edge of the metal. The paper is folded into the required shape, and pressed against the points of the pins, which are then relieved from the holder; and the next row is arranged in like manner.

Of these operations, drawing the wire, cutting it into lengths, cutting the heads from the coils, and tinning, are performed by men; the rest by the women and children.

The above description relates to the manufacture of pins by hand. It must now be stated, however, that most of the operations have gradually been brought within the scope of machinery. One of the earliest pin machines was that of Mr. Rundy. This machine fixed on the heads in the old manner, but more firmly. Each head was fastened by one blow, and several pins were operated on at the same time. Since that time several other machines have been invented for forming the head out of the stem of the pin itself, by pressing a small part of the end of the stem into a hollow die. A large proportion of the pins now manufactured are made in this way, and are much superior to those made in the old fashion. One objection however has been urged against them. It is stated that to form the head in this manner by pressure, the wire requires to be very soft, and consequently the pins will easily bend; but this evil has gradually been somewhat lessened. In Wright's pin-making machine, motion is given either by manual power or by machinery to a strong axis working in collars. This main axis carries several cams or excentric wheels which put forward at each revolution as many levers or slides at right angles to the main axis. These levers return to their former situation as soon as the cam ceases to operate by means of a strong spiral spring attached to each; at the other ends of these slides the different operations are performed. A coil of brass-wire of the requisite size is placed upon a reel and spindle, and the end is drawn through a set of zig-zag pins as before described for straightening the wire, and placed between the teeth of a strong pair of pincers. This is all that is necessary to be done before setting the machinery in motion. The first slide then moving forward shuts the pincers upon the wire and instantly carries it forward into a nipping-gauge which closes and cuts off sufficient for one pin. This length can be regulated by the adjustment of a small screw attached to the first slide. The piece thus cut off is carried by an ingenious little adaptation called a carrier to the next operating slide. These carriers are four in number, mounted on a bar at right angles to the working slides, and parallel to the main axis; this bar has a motion given to it in the direction of its length, and moves once for every pin-length of wire cut off by the gauge before mentioned. The carriers themselves are made somewhat in the manner of a pair of pliers, the under chap being kept up to the other by a spring. The juncture of these chaps is exactly opposite to the pin, which is forced between the chaps and carried to the next operation. The piece of wire is deposited by the first carrier in the centre of a chuck attached to a small mandril, which by a moveable lever clutches the pin; the instant this is done, the frame which supports the mandril is tilted so as to bring the point of the pin down upon a revolving steel mill just below it; a lever or finger then presses the end of the wire upon the mill, and at the same instant the mandril carrying the pin is set in motion. The wire is thus ground to a point; the mandril frame then rises, the mandril itself is brought to rest, the pin released, and conveyed by the second carrier to a finer mill, where the point is completed by exactly the same process as the preceding. It is then taken by the third carrier to the first heading die, where the body of the pin is firmly held while a steel punch advances against the end of the wire, and forcing it into a hollow in the die, partially forms the head. The last carrier then takes the pin, and placing it in another die, the head is completed by another punch; a small forked lever then draws the finished pin from the die, and drops it into a receptacle below. The pins are then tinned in the manner previously described. These operations are carried on by the machine simultaneously, and each occupies the same time; five pins being constantly under operation in the different stages; the machine will produce fifty or sixty pins per minute, and only requires the attendance of one person.

The patent method, just adverted to, was devised by an American of Massachusetts, but was first tried in England. A large factory was set up for the purpose at Lambeth, stocked with sixty of the pin-making machines. A difficulty at first arose in heading the pins; and a new machine was invented for this purpose. A lengthened period of ill-success brought on the ruin of the company by whom the enterprise was conducted. Mr. Taylor, one of the sufferers by the scheme, bought the machines at a low price, took them down to Stroud in Gloucestershire, made several improvements, procured the assistance of capitalists, and established a solid-headed pin manufactory. This led to the establishment of others; and Stroud is now one of the head-quarters of the trade.

America was supplied with pins from England until 1812; when the war between the two countries checked the import, and set the inventors to work. Manufactories were established at New York and elsewhere; but when the war ended, the United States were suddenly glutted with English pins at a price so low as to ruin these enterprises. Gradually, companies were formed (as is usual in the United States) to conduct the manufacture by new machines; and at the present time, some of these companies conduct the operations on a very large scale, making eight or ten tons of pins per week each. The Americans have been successful in inventing machines whereby the papering of pins can be conducted with great expedition.

PIN-MONEY. Gifts by a husband to his wife for the purchase of apparel, ornaments for her person, or for her private expenditure, are called pin-money; and such gifts may either be made during marriage, or, what is the more usual case, a sum of money for that purpose may be secured by settlement, or by articles executed before marriage. It is only money secured before marriage that is properly called pin-money; for a gift of money to the wife after marriage is liable to the husband's debts; but a provision for pin-money is not so liable, and the wife is entitled in all cases to such money, and to her savings out of it, and things bought with it.

Several of the questions upon pin-money have arisen after the husband's death when arrears have been claimed by the wife; and it is the general rule that she can only claim arrears of one year's pin-money if she has been supported by the husband with necessaries during the time that such arrears have accumulated, it being presumed that she has waved her claim to pin-money; but she may by evidence rebut such presumption.

If the husband leave a legacy to the wife equal to the arrears of pin-money or more, such legacy, according to the general rule as to the satisfaction of debts by the giving of legacies, will be considered as a payment of the arrears due at the time when the will was made. If a wife elope and live apart from her husband, either in a state of adultery or not, she does not thereby forfeit her right to her pin-money, and she may recover it.

PINE-APPLE, the fruit of the *Ananassa sativa*, Lindl., a tropical plant, indigenous to South America and some of the West India Islands. It has become so perfectly naturalised in many parts of the hot regions of Asia and Africa, that it has been thought to be likewise a native of those countries. It was, however, first introduced into Europe from South America, and, as it is recorded by M. Le Cour of Leyden, about the middle of the 17th century: from Holland it was brought to this country in 1690, by the Earl of Portland, according to the Sloanean MSS. in the British Museum. There is a painting, formerly in the collection of Horace Walpole, in which Charles II. is represented as being presented with the *first* pine-apple by Rose, his gardener; but there are some doubts whether that fruit was grown in England or obtained from Holland. It may, however, be fairly concluded that pine-apples were exceedingly rare in this country, even at the tables of the nobility, in the beginning of the last century; for in 1716, Lady Mary Wortley Montagu remarks that pine-apples were on the electoral table at Hanover when she was there in that year, on her journey to Constantinople; and she states that she had never previously seen that species of fruit. ('Letters of Lady M. W. Montagu.') Since that period the cultivation of the pine-apple has been prosecuted with perseverance in Britain, but frequently the results have been very disproportionate to the expense incurred. At the present day the pine-apple in England is so abundantly produced, that although expensive, it is very common. Its delicious flavour, and the noble appearance which a well-grown fruit exhibits, render the cultivation of it a special object of horticultural enterprise and skill.

As notwithstanding the many treatises that have been written on the subject, failures in the production of fine fruit continue to occur, it seems desirable to point out in what the mismanagement of a gardener is most likely to consist, and how he may apply the directions to be found in books of gardening with least chance of failure.

It has been already stated that this plant is an inhabitant of the tropics, and, it may be added, near the level of the sea. The latter circumstance it is necessary to remark, because if it were a mountain plant, even though tropical, it might be natural for it to endure a comparatively low degree of temperature. But according to Beyrich ('Gardeners' Magazine,' iii. 442), "the pine-apple in its wild state is found near the sea-shore, the sand accumulated there in downs serving for its growth, as well as for that of most of the species of the same family. The place where the best pine-apples are cultivated is of a similar nature. In the sandy plains of Praya Velha and Praya Grande, formed by the receding of the sea, and in which no other plant will thrive, are the spots where the pine-apple grows best." The temperature at the level of the sea at or near the equator varies but little throughout the year; for instance, the mean temperature of the warmest month at Cumana, 10° 27′ N. lat., is, according to Humboldt, 84·38°, and that of the coldest 79·16°. At Havanna, on the skirt of the tropics, the mean of the warmest month is 83·84°; that of the coldest 69·98°. At Vera Cruz the mean temperatures of the warmest and coldest months are respectively 81·86° and 71·06°.

In conformity with the above, and also from the results of experience, it may be stated that the artificial temperature of the atmosphere in which the pine-apple is intended to be grown should have a mean of about 80°; or a minimum not lower than 70° at any time of the year, and a maximum not higher than 90°. When, from the shortness of our days in winter, there is a deficiency of light, and when forcing the plant in its absence would produce only imperfectly formed tissue, 70° will be proper. In summer 80° to 85°, or in the case of fruiting plants, from that to 90° will not be too much. The maximum by sun-heat may extend higher, but 100° should be its limit.

With regard to bottom-heat, it should be in imitation of the heat of the tropical soil; and this varies even less than the temperature of a tropical atmosphere. The mean temperature of the earth is generally supposed to be somewhat higher than the mean of the atmosphere, owing to the greater capacity of the soil for retaining caloric. The discrepancy, however, cannot be great; and if the mean atmospheric temperature at the equator be from 80° to 84°, as has been ascertained from numerous observations, the temperature of the soil, it may be presumed, will not average lower; nor will it be many degrees higher where moisture sufficient for vegetation exists, as is generally the case in islands; although on continents it becomes so great as to reduce the soil to a desert. The temperature of the earth a foot below the surface, in New Granada, is 85° during summer, according to a correspondent of Mr. Hay ('Gard. Mag.'); and this degree of heat will be found a very good medium for the roots of the pine-apple. Bottom-heat then should never be allowed to fall below 75°, nor rise higher than 90°.

Pine-apples can be raised from seeds, but in England this is rarely done except for the purpose of procuring varieties. They are propagated usually from suckers. Formerly the crowns were used, but the suckers are found to be more early productive. The soil in which they are planted requires to be rich. A fresh yellow loam, strong, but by no means of a binding nature, with which is mixed a quantity of cow-dung, will answer very well. The pots require to be well-drained, and over the drainage some pieces of turf may be placed. Manure-water, made by steeping sheep's-dung or cow-dung, is occasionally applied, care being taken that it be properly diluted. If the plants are found not to be thriving, they may be shifted, without hesitation, at any period of their growth.

It is very important that a perfect drainage be at all times maintained. When pots are plunged in tan, the worms are apt to close the holes in the bottom of the pots by their excretions; or a stoppage may occur in consequence of the pressure of the pot upon the tan when it wastes and becomes capable of being rendered compact. From whatever cause the defect proceeds, a good preventive may be easily effected by simply plunging an empty pot, with its *mouth downwards*, and on this placing the bottom of that containing the plant, closing the tan round the sides of the latter in the usual way. If at any time the tan should become too hot, it may be partially removed from the sides of the pot.

Moisture is essential for the growth of the pine-apple. The condition of the soil in the pots will of course indicate whether water should be applied or withheld. But in summer the atmosphere should be kept moist by syringing, particularly before shutting up at night. No water should on any account be used of a temperature many degrees lower than that of the soil in the pots where the plants are growing; it should not, in short, be applied lower than 75°, and 80° will prove a good medium. When the fruit is ripening off, moisture of course should be withheld; and in damp cloudy weather in winter, when it is an object to restrain rather than promote growth, they should be kept rather dry than otherwise. Moisture will not prove injurious when it is accompanied by a sufficiently high temperature and a due share of light. The mode of heating by means of hot-water pipes is undoubtedly the best for pine-stoves; and steam from the boiler should be at command, so that it may be introduced to the interior of the house as occasion requires.

Pine-apples may be grown under various modes of treatment. Instead of being confined in pots, they are sometimes planted in a bed of soil. This has been found to answer very well where good drainage was secured, and where a proper degree of bottom-heat could be applied. They have also been grown in pots placed on shelves or on sand; this mode, however, has not proved fully successful, for the roots are subjected to vicissitudes consequent not only upon the variations in the temperature of the atmosphere of the house, but also its hygrometrical conditions.

A principal cause of failure in the cultivation of the pine-apple appears to have arisen from the idea that the plants will bear a much lower degree of temperature than that above pointed out as being natural to them. They will *apparently* do so; but although the plants may continue to have a healthy appearance, yet experience proves that their vital energy is interfered with, and their powers of organisation diminished, as is continually indicated by the fruit-stem being sent up with only a few imperfect pips. The stagnation of water about the roots from defect of drainage, too much heat and moisture, or too much heat and dryness, or checking the plants by cold in order to bring them to a fruiting condition, instead of forwarding them naturally to that state, are other sources of failure on the part of cultivators. With regard to the last, the only method that ought to be taken to bring on the time of fruiting is to inspissate the sap, and to augment the amount of secretions by gradually withholding moisture and increasing the temperature, at the same time admitting a little more air than usual; and after this, by the sudden application of a brisk temperature with more moisture.

To richly manured soil the large size of the pine-apples produced in England may be attributed; and to the means that cultivation under glass affords of progressively inspissating the juices towards the period of ripening, may be ascribed the superiority of the fruit to that produced in countries where the plants are indigenous, as alluded to under Ananassa *sativa*, in Nat. Hist. Div.

Pine-apples are now cultivated to a large extent in the Bahama Islands for the English market.

PINE APPLE, *Essence of.* [Butyric Acid.]

PINIC ACID. [Turpentine.]

PINIPICRIN ($C_{44}H_{36}O_{22}$?). An amorphous bitter organic substance contained in the leaves of the *Pinus sylvestris.* It is soluble in water and in a mixture of alcohol and ether.

PINITANNIC ACID. [Tannic Acids.]

PINITE ($C_{12}H_{12}O_{10}$). A saccharine substance produced by the action of fire upon the trunk of the *Pinus Lambertiana*, in California. It is eaten by the Indians. It does not ferment.

PINK. The flower so called (*Dianthus plumarius*) belongs to the genus Dianthus, to which also belong the carnation (*Dianthus caryophyllus*), the sweet-william (*Dianthus barbatus*), and others, and the cultivation of all of them is similar. Although some of the species are indigenous to Great Britain, by far the greatest number are natives of the southern parts of Europe; abounding in Germany, Switzerland, Italy, and along the shores of the Mediterranean, Black, and Caspian Seas, inhabiting rocks, mountains, and dry, warm, stony places most frequently, although occasionally living in sandy and damper places.

It is therefore obvious that the gardener must pay special attention to this peculiarity, and guard by every means in his power against the access of wet, unless when the plants are in a state of free growth. In the winter, when they are at rest, they bear moisture very impatiently. It is therefore either upon rockwork or in pots housed in winter that the species of Dianthus are best preserved. The soil in which they are planted should consist of equal quantities of good fresh loam and vegetable mould, to which may be added a little horse dung and sand, the whole to be mixed well, and allowed to remain for a season before being used.

All the species may be propagated either by seeds or by layering or piping. Both operations should be performed about the end of May or beginning of June. Layering is decidedly the surest method, as the young shoot derives support from the parent plant until it has protruded rootlets of its own for nourishment. In this operation gardeners generally practise a method technically called tongueing, which is simply making a slit with a knife, from a little below the joint, up through its centre, and then carefully pegging the young shoot down as in the common way. Pipings are a sort of cuttings, and will root freely in a melon or cucumber frame, which can often conveniently be applied to this purpose in the end of the season; but as artificial heat is not essential to success, those who have not this convenience may succeed very well with a small hand-glass.

If the pipings are not in a shaded situation, it is necessary to shade them when the sun's rays are powerful; because the rootlets are for some time insufficient to supply the stem with fluid enough to counteract the effects of evaporation. It is the want of due attention to this which causes the result of propagating the Dianthus by pipings to be considered uncertain: if shade and moisture are supplied for a sufficiently long time, there is little risk of the pipings not forming young plants.

When the young plants are rooted they should be transplanted into beds, about 6 inches apart; the soil of the bed being a rich loam and not less than a foot in depth, and well drained. As they begin to bloom remove all but two or three of the flower-buds, and the flower-stems should be supported by being tied loosely to sticks.

PINK SALT ($NH_4Cl, SnCl_2$). A double chloride of tin and ammonium, used as a mordant by dyers.

PINK SAUCERS. [Carthamin.]

PINT, the half of a quart, and the eighth part of a Gallon, which is the standard measure connected with the pint.

PINUS BALSAMEA. [Balsam, *Balsam of Canada.*]

PIONEERS. There are thirteen picked men (artisans) in each regiment of infantry who act as pioneers: these carry no muskets, but a sword with a saw back which acts as a weapon, and also as a tool. Besides which a regular complement of tools, such as picks, shovels, felling axes, saws, crowbars, is divided amongst and carried by the men, slung on their shoulders, or strapped to their backs. Pioneers are employed in the field in removing obstacles, and on the line of march in rendering posts defensible, doing repairs in camp, or directing working parties, &c.

PIPE (measure), a name given to two hogsheads of the old wine measure; two hogsheads of ale or beer were called a butt.

PIPE. A column of air contained in a tube and maintained in a state of vibration yields a musical sound, depending upon its length and (slightly) upon the state of the atmosphere. Our object in the present article is to give such an account of the theory of a musical pipe as may, with the articles Acoustics, Cord, Harmonics, Scale, Temperament, &c., complete the statement of the leading principles of sound and the doctrines of music.

In this subject a distinct line should be drawn between those circumstances which are of easy and difficult explanation: for example, to a person who thoroughly understands the composition of waves moving in opposite directions [Acoustics], it is not difficult to point out what the state of a pipe must be when in musical vibration; but to explain how the action of a current of air, as in the common flute, or the joint action of the air and a reed, as in the clarionet or reed-stops of an organ, produces and maintains this state of vibration, is quite another thing.

We shall first consider the pipe in a state of continued sonorous vibration (no matter how produced), yielding the lowest note which it will give: let it be a simple pipe open at both ends, and let it be sounding, say the C of the treble clef, which note requires 258 double vibrations per second. If we now remember that the air at the two extremities is in communication with the outer air, we see that no condensation or rarefaction can take place at those extremities, or only very small ones compared with those which take place in the interior of the tube. To get approximately at the conditions of vibration, let us suppose that no condensation or rarefaction takes place at the extremities. We then see [ACOUSTICS] that the state of the pipe, its two extremities never being condensed or rarefied, is as it would be if two waves of sound were travelling in opposite directions, every particle of the interior being affected by the joint condensations and velocities of both. Moreover, the distance between two uncondensed particles is always the whole length of the wave of condensation or that of rarefaction, or a multiple of this length; that is, the pipe must be either the half-length of a double wave or a multiple of this half-length. When the pipe sounds the lowest note, it must give the longest wave; that is, the length of the pipe must be that of the simple wave of condensation or rarefaction. Hence, the lowest note which a pipe can yield, which is called its *fundamental* note, is that belonging to a double wave of sound which is double of its length. Each double wave answers to a complete or double vibration of a string.

To compare this result with practice, let us suppose sound to travel at the rate of 1125 feet per second (temperature 62° Fahr.). The note C having 258 double vibrations per second, this 1125 feet must contain 258 double waves, or each double wave must be 4·36 feet. The single wave then is 2·18 feet, or 2 feet 2 inches and ·16 of an inch, which is the *theoretical* length of the pipe. Now the organ-builders say 2 feet [ORGAN, CONSTRUCTION OF], but this of course is a rough description, since the French organ-builders also say 2 feet (according to Biot), and the French foot is longer than the English. Further on in the article referred to we see 2 feet 2 inches given as the length of this C in an open pipe (the dulciana), and 1 foot 1 inch in a stopped pipe (the stopped diapason), which, as we shall presently see, ought to be half as long as an open pipe. The common flute, when everything is stopped, gives this same C, and the length from the embouchure (or mouth-hole) to the end of the instrument is a little more than 2 feet, but certainly never 2 feet 2 inches. It must be remembered however that this instrument is made up of the flute (so called) and the player, whose lips, when they come over the embouchure, confine the air, and are equivalent to a slight lengthening of the pipe. It is not the manner of blowing which does this, but the approach of the lips, as may be thus shown. Take a common flute, and without holding it to the lips, strike the uppermost hole with the finger; a faint sound will be heard. Now approach the lips to the embouchure, but without blowing, and then strike the same hole with the finger; another faint sound will be heard, decidedly flatter than the former. It is well known to those who play on this instrument (to those who play in tune at least) that drawing the lips back, so as not so much to confine the air contiguous to the embouchure, sharpens the tone, and what some persons call *humouring* the instrument means continual alteration of the position of the lips, so as to shorten or lengthen the pipe by turns, according to the note to be sounded. It is also well known to players that this humouring can be carried to a much greater extent with the high notes than with the low notes; but so little were the practical musicians in connection with the theoretical in the time of Daniel Bernoulli (who first gave the mathematical theory of this subject), that this simple fact was only discovered by him from a new and somewhat complicated experiment.

In the preceding theory all the parts of any section of the pipe perpendicular to its axis are supposed to vibrate in the same manner. This cannot be the case in the common flute or in the organ-pipe, in which the cause of condensation is supplied at the side; and in fact all experiments in which the cause of undulation has been equally applied over all the parts of a section perpendicular to the axis, have agreed in the result that the time of vibration is wholly independent of the diameter of the tube: while those in which the same was not equally applied give the result that the greater the diameter the lower is the tone. Moreover, when an orifice is made in the side of a pipe, as in the flute, it is not equivalent to the formation of a new pipe terminating at that orifice, though the results are somewhat resembling. Any note between the fundamental note and its octave may be obtained by an orifice of one size or another made at or near the middle of a pipe.

We have seen that we may suppose the extremities of the open pipe to contain between them 2, 3, &c., half-waves, which, the whole pipe being one half-wave in length, will give the HARMONICS of the fundamental note. This subject is sufficiently treated in the article cited.

Various instruments yield different harmonics more or less readily; the general rule being that the more violent the agitation which produces the sound, the larger the number of half-waves formed in the tube, and the higher the harmonic: also that a certain diameter, the larger the greater the length of the tube, is necessary to the production of the fundamental note. Thus, if an organ-pipe be too small in the bore, it will yield the octave of the fundamental note; or if the latter, only with great attention to the *voicing*, or adjustment of the orifice through which the wind enters. If the bore of a flute be too narrow (which we imagine to be the case in modern instruments), the lower notes will be difficult to obtain. And the various harmonics are produced with very different degrees of facility; a circumstance of which the theory can give no account. Thus, players on the trumpet find it exceedingly difficult to produce that tone which divides the instrument into seven parts, or the flat seventh in the third octave above the fundamental note; while in the flute there is no moderately skilful player who cannot produce it. It is to be observed however that all pipes of the trumpet class are of tapering diameter; and though they agree in all material points with the theory of cylindrical and prismatic pipes, it is not remarkable, in the present state of the mathematical analysis of this subject, that they should present circumstances difficult of explanation.

It will be obvious, from the considerations in ACOUSTICS, that when the extremities of the pipe contain between them n half-waves, there will be $n+1$ points (the orifices included) at which the velocities are always greater than elsewhere, and no condensations or rarefactions; and n points (in the middle of the subdivisions), at which the condensations or rarefactions are always greater than elsewhere, and which are always at rest or nearly so. These immoveable points are called *nodes* of vibration; and there is one of them in the middle of the tube only when the number of half-waves in the pipe is odd.

Let us consider the case of a pipe with one end closed. It is obvious now that the open extremity is a point of no condensation, while the closed extremity must be a node, or point of no velocity. Hence the tube must be the half of an odd number of simple waves in length, twice the tube must be an odd number of simple waves, and four times the tube an odd number of double waves in length. Hence the fundamental note belongs to a double wave of four times the length of the tube; so that the fundamental note of a pipe closed at one end is an octave lower than that of the same pipe open at both ends. It is the same thing to say that a pipe of half the length of an open pipe, closed at one end, gives the same note as the open pipe. This is the reason why the pipes of the stopped diapason stop of an organ are halves of the lengths of those of the open diapason.

Again, since the double length of the pipe is an odd number of simple waves, the harmonics which the pipe can yield are not the complete set yielded by the open pipe of double the length, but every other one, beginning from the fundamental note. The number of vibrations per second being 1, those of the harmonics producible by the pipe closed at one end are 3, 5, 7, &c. We will leave the pipe closed at both ends (a matter of no practical concern, since its sound could not be heard) to the student; the result he should arrive at by the preceding considerations, is that it is in all respects analogous to the vibrating CORD fixed at both ends. But he must not infer, by a reversed analogy, that the vibrations of an elastic body fixed at one end (as the spring of a tuning-fork) answer to those of a pipe closed at one end, since their law is very different.

It is usual first to give the theory of a closed pipe, and then to suppose the open pipe made of two closed pipes, with their closed ends together, and their closing diaphragms removed. The opposition of the vibrating movements will then keep the particles in the middle at rest. This is a sufficient explanation of those modes of vibration of the open pipe in which there is a node in the middle.

We now come to the explanation of the manner in which the sonorous vibration of a pipe is maintained. If we suppose a vibrating body placed at the orifice, it is found that if the vibrations of the body be equal or nearly equal to those of the fundamental note of the tube in the preceding theory, or one of its harmonics, the sound of the vibrating body is reinforced by the tube. A slight alteration of the tube, though it may sharpen or flatten the note, does not by any means produce such a difference as would be caused by the same alteration, if the sound were caused by the tube alone. We do not intend to go into this subject; the reader may find it discussed, both mathematically and experimentally, in a paper by Mr. Hopkins, published in the fifth volume of the 'Transactions of the Cambridge Philosophical Society.'

When the sound is caused by a current of air, as in the common flute or simple organ pipe, a tolerably satisfactory explanation of the phenomena has been given in the case of the pipe closed at one end (to which writers have confined themselves); but none whatever in that of the pipe which is open at both ends. In the former case, as in a reed of the Pan's pipe, a current of air is directed laterally over the mouth of the pipe, with a slight obliquity of direction. A condensation is therefore produced in the tube, which travels to the closed end, and is there reflected; so that by the time the condensation has travelled over twice the length of the tube (down and back again), the whole condensation, such as it was when it began, is doubled. Hence the air in the tube has now become more powerful than the external stream, and the condensed portion begins to be discharged. This continues until not only the whole of the condensation is discharged, but also until all the velocity of the issuing particles has been destroyed; and this is not done until the effect of that velocity has produced a rarefaction in the tube. The effect of the condensation is destroyed in the same time as that in which it was produced; and hence the complete undulation belonging to the whole length of the closed tube is four times the length of the tube. Imperfect as the preceding explanation is, we know of no way of applying even so much to the open tube.

It is also to be noted that the whole of the preceding theory is but an approximation. The extremities of the open tube are not points of absolute non-condensation and non-rarefaction, but points at which the condensations and rarefactions are least and small. Similarly the nodes are not points in which the air is absolutely at rest, but points at which the motion is least. The extensions of this theory, however, important as they are in a physical point of view, are not essential to that fundamental explanation of the musical phenomena of a pipe, to which we have expressed our intention of confining ourselves in the present article.

PIPE, a circular or square artificial channel for the conveyance of watery fluids, either under pressure, or flowing freely, or for the passage of æriform fluids, or of sound. According to the almost endless varieties of uses to which pipes may be converted, and to the positions in which they may be placed, the materials of which they are formed may be modified in an equally varied manner. A few of the more prominent uses, and of the more generally adopted materials, are therefore all that it will be possible here to allude to, under the general name of *pipes*.

For the purpose of removing rain-water from buildings the ancients, and even occasionally the moderns also, have resorted to the use of earthenware pipes of ordinary clay baked in kilns, but of late years lead, zinc, or iron pipes have been used in preference either to the earthen, or the stoneware pipes. Copper pipes are commonly used for the ascending pipes from force pumps; but the distribution of water horizontally is almost always effected through cast or wrought iron, lead, or tin pipes. Gas is distributed through cast iron mains, wrought iron service-pipes, or through small pipes of tin, or of mixed metal with a tin base. The foul waters from modern houses are removed through glazed stoneware drains, whilst land drainage waters are removed by means of red earthenware pipes. Until within a very few years the whole of the water supply of our towns was carried through elm pipes; and at the present day wood is still used for conveying water in agricultural districts, whilst that material is considered to be the most fitted for the conveyance of such fluids as tan liquor, or the bilge waters of ships. Indian rubber and gutta percha pipes are sometimes used for garden and irrigation purposes; and leather pipes are almost universally used for fire engines, or for moveable pumps, of any kind.

Smoke, hot air, and hot water are conducted through pipes or channels formed, as the case may require, of ordinary bricks; of moulded bricks, of glazed brick, or stoneware pipes; or of cast or wrought iron, or of copper, zinc, lead, or tin; and in the construction of boiler furnaces, of drawn brass. Sound is conveyed through metal pipes, or through Indian rubber, or gutta percha tubes.

The stoneware and cast iron pipes certainly are the most durable under ground; but the chemical natures of the fluids conveyed, and of the ground itself, vary within so wide a range as to render it necessary to exercise great circumspection in the choice of the materials to be used. Every case must in fact be regarded on its own merits; observing simply that metals are peculiarly liable to decay under the continuous action of dilute acids; and that such decay will be accelerated if any galvanic action should be superinduced. In earth, it may be taken as a general rule that stoneware pipes will last longer than metal ones; that lead will last longer than cast iron, and much longer than wrought iron or wood; and that both on the score of their rapid decay in such positions, and of their compressibility, the pipes made from vegetable substances, such as gutta percha or Indian rubber, are very objectionable for use in the ground. [SEWERAGE; WATER SUPPLY.]

Cast iron pipes are cast vertically in loam moulds; wrought iron pipes are either lapwelded or brazed; lead pipes are either soldered on their longitudinal seams, or they are forced by hydraulic pressure upon a mandril, so as to ensure their perfectly homogeneous character; tin pipes, and copper or composition pipes are usually brazed, but in unimportant works their longitudinal joints may be soldered like those of the lead pipes. The end joints of cast iron pipes are either made with a spigot and faucet joint, which may be either turned so as to fit quite tight, or be left large enough to receive a packing of yarn, white lead, and melted pig lead; or they are made with flange joints connected by means of bolts and washers. The ends of wrought iron pipes may be connected by means of screw couplings, or by flanges; and the end joints of the more easily soldered materials are made by that process, taking care of course to provide against the irregularities of contraction, or of expansion in the pipes. It is precisely on account of the play afforded by the spigot and faucet joints of cast iron pipes, that they are adopted when any danger of changes of temperature exists. As it is not possible to make a screwed joint with any description of earthen pipes, those articles are always made with spigot and faucet joints. The end joints of gutta percha and of Indian rubber tubes are melted, and both the longitudinal or the end joints of leather pipes are sewn or riveted; wood pipes have turned and bored joints fitting into each other, which are sometimes screwed together.

The strength of a pipe must be such as to ensure its resistance to the external and internal pressures it is likely to be exposed to; but, if it should work under pressure, the internal force will be, generally speaking, so much in excess of the external one, that it will suffice to consider the former condition to the exclusion of the latter. The usual formula for calculating the thickness of pipes is as follows: calling p, the pressure per square inch; r, the radius in inches of the interior diameter; and c, the cohesive strength of the metal per square inch; then $x = \frac{p\,r}{c-r}$: Mr. Hawksley adopts a rather simpler formula, namely: $x = 0{\cdot}18\sqrt{d}$; in which d = the diameter in inches. In practice, however, the theoretical thicknesses attained by either of these formulæ are exceeded, on account of the difficulty of securing good sound pipes, when the thickness is very small. Stone and earthenware pipes being usually made of large diameters, and being exposed to great external pressures and jars, seem to require greater thicknesses than are usually given to them; perhaps when their diameter exceeds 9 inches they ought, in the present state of the arts, to be made of such a thickness that the latter dimension should be equal to $\frac{1}{12}$th of the diameter at least.

Rain-water, or other metal descent-pipes are made with projecting ears upon the socket ends, for the purpose of receiving the nails by which they are to be fixed one above another. In these cases the end joints are not required to be fitted hermetically.

PIPE-OFFICE, or more properly the Office of the Clerk of the Pipe, an ancient office in the Exchequer, abolished with that of comptroller of the pipe, by 3 & 4 William IV., c. 99. The records of the office were then transferred to the custody of the king's remembrancer. See the Report of the Commissioners on Public Records, 1837, p. 198.

PIPER, MEDICAL PROPERTIES OF. Pepper. According to the analysis of Pelletier, black pepper contains an acrid soft resin, a volatile oil, piperine, extractive, gum, bassorine, malic, and tartaric acids, salts, &c. White pepper is the same fruit deprived of its outside rind.

The odour of pepper is probably due to the volatile oil, which is not acrid; the pungent taste is most likely owing to the resin. Piperine is generally yellow, from the presence of some resin, to which it is most probably indebted for its virtues, as when purified by means of ether from all resin, it seems devoid of power, and the febrifuge virtues ascribed to it belong in reality to the acrid resin. Pepper is much more employed as a grateful condiment than as a medicine, and it appears to be essential to the process of digestion in hot countries. Of 50,000,000 pounds of pepper collected, one-third only goes to Europe, the greater portion being consumed by the Chinese. Its moderate use with cold raw vegetables or other substances difficult of digestion is to be approved; its employment in excess is hurtful to the liver, and a very large dose may prove fatal, not only by exciting inflammation of the stomach, but by an impression on the nervous system. Black pepper readily poisons hogs.

Whole pepper is a popular remedy against intermittent fevers, and impure piperine is used beneficially in like cases.

Piper betle and piper siriboa, besides the use of them in chewing, are also employed, in the form of the freshly expressed juice, as a febrifuge medicine, and as an antispasmodic, especially against obstinate dry coughs.

Piper methysticum, by fermentation, yields a powerfully intoxicating drink. Matico is yielded by a plant called *Artanthe elongata*, formerly considered a species of piper. [MATICO.]

PIPERIDINE. [PIPERINE.]

PIPERINE ($C_{68}H_{38}N_2O_{12}$?). An alkaloid contained in the different varieties of pepper. [PIPER, in NAT. HIST. DIV.] It was discovered by Oersted in 1819, and is best obtained by the following process.

White pepper, coarsely comminuted, is digested in alcohol, the latter recovered by distillation, and the residual extract treated with a small quantity of solution of potash to remove resinous matter; the resulting impure piperine is washed with water and obtained pure by one or two recrystallisations from alcohol. Piperine occurs in colourless prisms, it is insoluble in cold water, only slightly so in hot water, tolerably soluble in ether, and readily so in alcohol, the essential oils, and acetic acid. Heated to about 212° Fahr. it melts, and at a higher temperature decomposes. Concentrated sulphuric or hydrochloric acids dissolve it, and nitric acid oxidises it to a brown coloured substance, that dissolves in caustic potash with production of a beautiful blood-red colour.

Piperine is but a feeble base. It absorbs hydrochloric acid gas with avidity, a stable hydrochlorate being formed. The *chloroplatinate* ($C_{68}H_{38}N_2O_{12}$, HCl, $PtCl_2$) forms large orange-coloured crystals, very soluble in water or alcohol.

Piperidine ($C_{10}H_{11}N$) is obtained when one part of piperine is distilled with three parts of potash-lime. It is a light oily body that rises to the surface of the distillate on the addition of solid hydrate of potash. It is volatile, boiling at about 222·8° Fahr., colourless when pure, has a powerful ammoniacal odour, and is very soluble in water. Its constitution has not yet been satisfactorily ascertained; it is usually looked upon as ammonia in which two equivalents of hydrogen are replaced by the diatomic radical *piperyl* ($C_{10}H_{10}''$ or Pp''). Piperyl may however be a compound, and contain two radicals ($C_x H_y + C_{10-x} H_{10-y}$), each capable of taking the place of an equivalent of hydrogen in ammonia.

Piperidine forms crystalline compounds with most of the acids. The *hydrochlorate* ($C_{10}H_{11}N, HCl$) occurs in long colourless needles very soluble in water. The *oxalate* ($2\,C_{10}H_{11}N, C_4O, 2\,HO$) also forms delicate needles.

Piperyl-urea, or the *cyanate of piperidine* ($C_2(H_2Pp'')N_2O$ or $N(H_2 Pp''), O, CyO$), is formed on boiling a solution of sulphate of piperidine with one of cyanate of potash; it may be obtained in long white needles.

Methyl-piperyl urea ($N(H, C_2H_3, Pp'')\,O, CyO$) and *ethyl-piperyl urea* ($N(H, C_4H_5, Pp'')\,O, CyO$) are produced by acting upon piperidine with the cyanates of methyl and of ethyl respectively.

By the action of the iodides of the alcohol radicals upon excess of piperidine the following bases are produced. They are oily liquids, have fixed boiling points, and form well defined crystalline salts with acids:—

Methyl-piperidine . . . . . $N\left\{\begin{matrix}C_2H_3\\Pp''\end{matrix}\right.$

Ethyl-piperidine . . . . . . $N\left\{\begin{matrix}C_4H_5\\Pp''\end{matrix}\right.$

Amyl-piperidine . . . . . . $N\left\{\begin{matrix}C_{10}H_{11}\\Pp''\end{matrix}\right.$

Excess of the alcohol iodide gives rise to iodides of the following ammoniums. By the usual oxide of silver method these iodides yield hydrated oxides:—

Dimethyl-piperyl-ammonium . . . . $N(C_2H_3)_2Pp''$
Diethyl-piperyl-ammonium . . . . . $N(C_4H_5)_2Pp''$

Piperyl-sulphocarbamic acid. Bisulphide of carbon combines energetically with piperidine (Cahours):—

$$C_2S_4 \;+\; 2C_{10}H_{11}N \;=\; C_{22}H_{22}N_2S_4$$

Gerhardt thinks the product may be piperyl-sulphocarbamate of piperdine, viz.:—

$$C_{22}H_{22}N_2S_4 \;=\; \left.\begin{matrix}N(CS_2)_2Pp'', S\\NHPp''H, S\end{matrix}\right\}$$

Piperyl-benzamide or *benzopiperide* $\left(N\left\{\begin{matrix}Pp''\\C_{14}H_5O_2\end{matrix}\right.\right)$ is formed on acting upon piperidine with chloride of benzoyl. It may be obtained in colourless prisms.

Piperyl-cuminamide $\left(N\left\{\begin{matrix}Pp''\\C_{20}H_{11}O_2\end{matrix}\right.\right)$ formed from piperidine and chloride of cumyl, crystallises in tables.

PIPERYL-BENZAMIDE. [PIPERINE.]

PIPERYL-CUMINAMIDE. [PIPERINE.]

PIPERYL-SULPHOCARBAMIC ACID. [PIPERINE.]

PIPERYL-UREA. [PIPERINE.]

PIQUETS, or PICKETS. All armies and smaller bodies of men, in camp or bivouac, are protected against surprise by small detachments of troops termed piquets, thrown out on their front and flanks. There are two descriptions of piquets, the outlying and inlying piquets, whose strength depend of course on the length of front to be watched and the liability of attack. The outlying piquet is advanced a considerable distance in front of the camp, while the inlying piquet generally remains in camp ready accoutred to turn out at a moment's notice to support the outlying piquets: communication between the two sets being maintained by sentries conveniently posted for hearing and observing any alarm in front, and if necessary by patrolling to the advanced posts. The general duties of the outlying piquets are to insure the safety and repose of the camp, to gain intelligence of the enemy's movements as early as possible, and even of his intentions by examining the peasantry, and to prevent his making reconnaissances; with this object they are posted with a chain of double sentries in front, on the same principle that light troops are extended to cover a line, with supports in their rear, and if far from the main body with a reserve also. Each company on piquet is divided into three reliefs, one relief being extended on sentry while the other two are in support, the sentries being relieved every hour during the night. As a further precaution against surprise, and as a means of obtaining information, frequent patrolling is directed along the front of the line of sentries, and, if the enemy's posts be far off, along the roads in their direction, as far as is deemed expedient. These patrols are preceded by feelers, quick intelligent men; and, avoiding all unnecessary firing, so as not to create false alarms, retire steadily, and if possible unobserved, on the piquets, on finding themselves in presence of the enemy. A strong patrol should always be sent out about an hour before daylight, when the whole of the advanced piquets are also got under arms, as this is the time when an attack is most likely to be made; for this reason, also, piquets are generally relieved at this hour, as a great accession of force is thus obtained. In the daytime the sentries should be on high ground, the better to observe the enemy's movements; whilst at night they should have the highest ground before them, in order to see an approaching party against the sky without being themselves seen. The duties of officers in command of piquets is to give immediate information of any signs indicating the intention of the enemy to make an attack, such as a strengthening of the outposts, unusual movement of troops, noise of artillery on the march, &c. Should an attack be made, the object of the piquets is by all means in their power to gain sufficient time to enable the main body in their rear to get under arms and prepare for action. Hence the posts should be strengthened by breastworks, abbatis, &c., which the piquet should defend as long as its flanks are not attacked. It is not the object of piquets that they should defend themselves to the last, or shutting themselves up in a house or enclosure be cut off, but rather that they should retire steadily on the main body, disputing every available obstacle; but, at the same time, in an extreme case an officer must remember that it is his duty to sacrifice himself rather than be driven in on the main body before it has had time to form.

PIRACY (immediately from the Latin *pirata*, and remotely from the Greek *πειρατὴς*) or robbery and depredation on the high seas, is an offence against the universal law of society; a pirate being, as Blackstone expresses it, "hostis humani generis." "With professed pirates," Lord Stowell observes (2 Dods., 244), "there is no state of peace. They are the enemies of every country, and at all times; and therefore are universally subject to the extreme rights of war."

Molloy, an ancient writer on maritime law, but whose doctrine it would be dangerous to adopt in these days, says, "If a piracy be attempted on the ocean and the pirates are overcome, the captors may immediately punish them with death, and not be obliged to bring them into any port, provided this occurs in places where no legal judgment can be obtained. So likewise if a ship be assaulted by pirates, and in the attempt they are subdued and taken, and carried into the next port, if the judge openly rejects their trial, or the captors cannot wait till judgment shall be given without certain peril and loss, they may do justice on them themselves without further delay or attendance." (Molloy, 'De Jure Maritimo,' chap. iv., sect. 12, 13.)

"There is said to be a fashion in crimes; and piracy, at least in its simple and original form, is no longer in vogue. There was a time when the spirit of buccaneering approached in some degree to the spirit of chivalry in point of adventure; and the practice of it, particularly with respect to the commerce and navigation and coasts of the Spanish American colonies, was thought to reflect no dishonour upon distinguished Englishmen who engaged in it. The grave judge (Scaliger) observes, in a strain rather of doubtful compliment, 'Nulli melius piraticam exercent quàm Angli.'" (Lord Stowell, 2 Dods., 374.)

The offence of piracy, by the common law of England, consists in committing those acts of robbery and depredation upon the high seas, which, if committed upon land, would have amounted to felony there. But by various statutes other offences are made piracy, especially dealing in slaves. (See on this point, Blackst. 'Com.' Mr. Kerr's ed., vol. iv.; and Abbott, 'On Shipping,' 140, 141, 142, 239.)

Persons guilty of piracy were formerly tried before the admiralty court, according to the rules of the civil law. This was altered by the statute 28 Henry VIII., c. 15, which enacted that the trial should be before commissioners of oyer and terminer, and that the course of the proceedings should be according to the common law. Further provision was made by the statutes 39 Geo. III., c. 15; 43 Geo. III., c. 113; 46 Geo. III., c. 54; and now, by the stat. 4 & 5 Wm. IV., c. 36, sec. 22, the trial of offences committed on the high seas is before the Central Criminal Court, or the judges at the assizes.

PISCES (the Fishes), the last constellation of the old zodiac. There is in the mythological stories (which are unworthy of note) a confusion between this constellation and Piscis Australis, presently to be noticed. (See Grotius, in his notes on Aratus.) The constellation consists of two fishes linked by a string attached to their tails: they are not close together, the upper one being close to Andromeda, the lower one under the wing of Pegasus. The rectangular figure mentioned in PEGASUS will be a guide to the position of the two fishes: the line of α Andromedæ and γ Pegasi being parallel to the body of one fish, and that of γ Pegasi and α Pegasi to the body of the other.

The principal stars are as follows:—

Character.	No. in Catalogue of Flamsteed.	No. in Catalogue of British Association.	Magnitude.
γ	6	8105	4
δ	63	222	4
ε	71	288	4
η	99	453	4
α	113	625	3

PISCIS AUSTRA'LIS, or AUSTRI'NUS, or NO'TIUS (the Southern Fish), one of the old constellations situated directly under Aquarius: the stream from the water-pot of the latter constellation finishes at the mouth of this fish. It contains a remarkable star of the first magnitude, Fomalhaut, which only just rises above the horizon in these latitudes; when on the meridian, it is nearly in the same vertical circle with α and β Pegasi.

The principal stars are as follows :—

Character.	No. in Catalogue of Flamsteed.	No. in Catalogue of British Association.	Magnitude.
ι	9	7557	4
θ	10	7583	4
β	17	7842	3
ε	18	7898	3½
α	24	7992	1

PISCIS VOLANS (the Flying-Fish), one of Bayer's southern constellations, situated between the South Pole and Argo. It contains no stars of conspicuous magnitude.

PISTOL. [Arms.]

PISTOLE. [Money.]

PISTON. [Hydraulics; Steam-Engine.]

PITCH. [Tar.]

PITCH IN MUSIC. [Acoustics; Tuning.]

PITTACAL. [Tar.]

PIVOT, in military manœuvres, is the officer or soldier stationed on the flank of a section, company, battalion, &c., on which it wheels.

PIX, TRIAL OF THE. [Coinage.]

PLACES OF ARMS, in fortification, are the enlargements in the covered way [Bastion] at the re-entering and salient angles of the counterscarp; the latter are termed *salient* places of arms, and are simply made by rounding the counterscarp; and the former, the *re-entering* places of arms, are formed by setting off demi-gorges of about thirty yards, and making the faces form angles of 100° with the adjoining branches of the covered way, as in Vauban's first system. These places of arms receive a considerable development in various systems, as in the modern system, where they are large and furnished with redoubts, and in the system invented by Chasseloup de Laubat, and called after him, where they form one of the principal points of defence.

PLAGAL, a term in old ecclesiastical music, relating solely to the Canto-Fermo, or Plain-Song, and signifying *collateral*. When the octave was so divided that the fifth was above the fourth, the mode or key was said to be *Plagal*.

PLAGUE. [Pestilence.]

PLAID, a chequered woollen cloak or mantle, the garb of the highlanders of Scotland, but worn also in that country by many of the lowlanders. In Gaelic it is termed *breacun-feile*, the chequered, spotted, or striped covering. The chequered patterns, by their varied colours, indicated among the highlanders the peculiar clan to which they belonged, and a detailed account of the patterns is given by Mr. R. M'Ian, in his 'Clans of Scotland Illustrated.' It was a part of the dress proscribed by the act of parliament of 1747, after the rebellion of 1745. The restriction was, however, afterwards repealed, and the plaid was made part of the uniform of what were called the highland regiments. It is also worn by the pipers of the Coldstream guards.

But the term plaid was not confined to the chequered cloth. Mr. Logan, in his 'History of the Gael,' says that it was frequently "woven of one colour, or an intermixture of the black and white, so often seen in Scotland to the present day." This was the shepherd's plaid, worn even yet by lowlanders, and sometimes called the maude. Jamieson, in his 'Popular Ballads,' calls it a sort of blanketing. It was also used by females, both as a shawl or mantle, and for other parts of dress. Thus Ramsay, in his 'Gentle Shepherd,' says that his heroine, Peggy, shall "change her plaiding coat for silk." The old "belted plaid" of the highlanders consisted of twelve yards of stuff, wound round the body, and girdled round the waist by a leathern belt, the upper end being left loose and thrown over the left shoulder, to which it was frequently fastened by an ornamental brooch.

PLAIN-CHANT. [Plain-Song.]

PLAIN-SONG, or *Cantus Firmus* (Lat.), or *Canto Fermo* (Ital.), a name given by the Church of Rome to the ecclesiastical chant. The *Plain-Song* is an extremely simple melody, if melody it may be called; it admits but one measure, the duple, and only notes of equal value. It is rarely allowed to extend beyond the compass of an octave, and never exceeds nine notes; and the staff on which the notes are placed consists of but four lines. The clefs are those of C and F. To St. Ambrose, archbishop of Milan, the church is supposed to be indebted for the regular form of the Plain-Song, and to the Pope St. Gregory, surnamed the Great, for having perfected and brought it into that state in which it still continues to be used in the Roman Church.

PLAINS. All those parts of the dry land which cannot properly be called mountainous are plains, and such compose by far the greater part of the earth's surface. Thus, for instance, it has been estimated that in South America the plains are to the mountainous country as 4 to 1. We are not aware that a similar calculation has been made for the other parts of the world, nor are there perhaps materials sufficiently exact for the purpose.

The word plain has but an indefinite meaning of itself, and seems to be rightly understood only when used in opposition to the word mountains, or when conjoined to the name of some known place, in which case it means the country itself so designated, or the environs of some particular spot. Thus we speak of the cities of the plains, the valleys of the plains, the plains of Lombardy, the plains of Quito, &c.

It were a great error to imagine that by the word plain a perfectly horizontal surface is always understood. In its usual acceptation it means a greater or less extent of country, flat in its general level as compared with a mountainous country. The more perfectly even and horizontal the surface, the better does it deserve to be called a plain, such as the plains of Venezuela and of the lower Orinoco, Mesopotamia, &c. But the surface of the ground may be gently waving, as Salisbury plain and the Ukraine; or more prominently undulated, as the plain round Paris; or it may be studded with hills, as the plains of the Cassiquiare; or it may be traversed by valleys more or less wide and deep, like that part of France which lies between the Loire and the Garonne; or intersected with deep ravines, as the central plains of Russia, without ceasing on such accounts to be a plain.

Plains have been divided into two classes, high and low; but a moment's reflection will show that such denominations can apply rigorously only to the two extremities of a scale of elevation, at the bottom of which would stand, for example, the delta of Egypt or the llanos of South America (which latter are raised only about 150 feet above the level of the ocean, and in some places even less), and at the top the plain of Antisana, 13,435 feet above the sea-level; whereas the greater number of plains are found at intermediate heights, as the following will show :—

	Feet above the Ocean.
The plains of Hungary	200 to 250
The extensive plains on the north of the old continent from the Schelde to the Yenisei . . .	250 to 300
Plain from which the Himalayas rise (average) .	300
Plains of Moscow	460
Prairie in lower parts of Illinois	400 to 550
Plains of Lombardy	500
Plains of Lithuania	600
Suabia	900
The plateau of Valdaï	1000
Auvergne	1100
Prairie of Southern Wisconsin	1100
Plains of India skirting the Himalayas, highest .	1200
Switzerland between the Alps and Jura . .	1400
Steppes of the Kirghis	1300 to 1600
Bavaria	1650
Plains of the two Castiles	1800 to 2100
Mysore	2300 to 2600
Table-land of Persia	3800 to 4200
Westernmost Prairies of Missouri . . .	5000
Eastern edge of the table-land of Abyssinia . .	7000 to 9000
Plain of Antisana	13,435
Table-land of Asia in Tibet	15,000

Though we generally regard those plains which are the least raised above the surface of the ocean as the lowest, it must not be forgotten that round the Caspian and Aral there are plains of many thousand square miles considerably depressed below the sea-level; as is also the case with the plain or valley of the Jordan.

The term *plateau* has often been given exclusively to elevated plains; but this also is incorrect, inasmuch as by a plateau is sometimes meant a great extent of country considerably raised above the rest of the land, and having its mountains, its plains, and its valleys, as is particularly exemplified in the minor plateau of Albania, and in the great plateau of Central Asia, described below.

Table-land, properly so called, is an elevated plain rising more or less abruptly from the general level of the country, and being, as it were, the broad and horizontal or gently undulating top of an immense mountain, as the Nilgherry district of India. Sometimes there are several such, set one upon the other, at least on one or two sides, when they are called platforms or terraces, as those on the eastern slope of the Cordillera of New Mexico.

Some writers regard the words plateau and table-land as merely the French and English names for the same sort of elevation. Humboldt is of opinion that these names should be confined to elevations producing a sensible diminution of temperature, and, accordingly, to such heights only as attain to 1800 or 2400 feet. Some again, as Balbi, give the name of plateau to all high and extensive mountain-tracts.

Generally speaking, the plains of Europe are of middling elevation, the extremes of high and low being principally found in Asia and America. Thus while the great plains of Central Asia, about Ladak, Tibet, and Katchi, and round Koukounoor and elsewhere, attain a height similar to those of Quito and Titicaca, or from 9000 to 12,000 and 15,000 feet, the great marshy plains of Siberia along the borders of the Frozen Ocean are very slightly raised above the sea-level, as is also the case with the plains of Bengal at the mouths of the Ganges, the whole of Mesopotamia, the Tehama of Arabia, &c.

The plains of India which skirt the foot of the southern face of the Tibetan table-land, for an extent of 1500 miles, nowhere have an elevation exceeding 1200 feet above the sea, the average being much less. "The greater part of the country between" the Sikkim Himalaya, forming part of that face, and the sea, as we are informed by Dr. Joseph D. Hooker, "is a dead level, occupied by the delta of the Ganges and Brahmaputra, above which the slope is so gradual to the base of the mountains that the surface of the plain from which the Himalayas immediately rise is only 300 feet above the sea." We have every reason to suppose that the plateau of Yarkend and Khotan, on the northern border of the table-land, like the country around Bukhara or Bucharia, lies at a very small elevation, probably not more than 1000 or 2000 feet above the sea, while the surface, as we know, and in agreement with a previous statement in this article, descends on the borders of the Caspian to 80 feet below that level.

The table-land of Tibet itself is the summit of a great protuberance above the general level of the earth's surface, of which the Kouenlun and Himalaya are the north and south faces, while the other mountain-ranges and intervening valleys commonly marked on our maps of Tibet are but corrugations of the table-land more or less strongly marked. In its general relief, however, the table-land is laid out horizontally, at a mean elevation of 15,000 feet. The Indus and Brahmapootra rivers maintain a course along the length of the summit of the table-land, and receive as they proceed the drainage of its entire breadth, with the exception, first, of an occasional strip along its southern edge, from which the water passes off more or less directly to the north through the Himalaya; and secondly, of some parts chiefly found in the northern half of the table-land, from which the water has no escape, but is collected in lakes in depressions on its very summit. The waters accumulated in these two streams are at length discharged by two openings in the Himalayan slope, through the plains of Hindostan, into the Indian Ocean. None of the drainage of the table-land, so far as is known, passes in the opposite direction through the northern slope. The waters of that slope itself exclusively flow down to the plains of Yarkend.

That portion of the table-land which forms a plain along the upper course of the river Sutlej, we are informed by Major R. Strachey (to whose researches, and those of his brother Captain H. Strachey, much of our present accurate knowledge of these regions is due), "lies immediately to the north of the British provinces of Kumaon and Gurhwal, and is about 120 miles in length, its breadth varying from 15 to 60 miles. Its surface, to the eye a perfect flat, varies in elevation from 16,000 feet along its outer edges, on the south-west and north-east, to about 15,000 feet in its more central parts, where it is cut through by the river Sutlej, which flows at the bottom of a stupendous ravine, formed out of the alluvial matter of which the plain is composed to a depth of 2000 or 3000 feet, and at its west end even more." But the table-land itself, it must be remembered, is a mountain-mass. "The so-called *plains*" of Tibet, Dr. Hooker remarks, "are the flat floors of the valleys, and the terraces on the margins of the rivers, which all flow between stupendous mountains," either those of the northern and southern slopes or faces, or of the corrugations already mentioned.

In South America, contrasting with the lofty plains of Quito, of Santa Fé de Bogota, &c., are the llanos and the plains of the Amazon; while in North America, the interminable prairies and the low swamps round New Orleans form a striking contrast with the Rocky Mountains and the elevated plains of Mexico.

Of Africa comparatively little is known; but if the plains of Lower Egypt and part of the Sahara are very low, there are high plains in some of the mountainous regions.

The great plateau or table-land of eastern Africa, according to Dr. Beke, to whose continuation southward of Dr. Rüppell's investigations we mainly owe our present knowledge of it, begins to the south of the country of Taka, in about 15° of north latitude, where the anticlinal axis between the Nile and the Red Sea rises rapidly till it attains an elevation of 7000 or 8000 feet above the level of the ocean. At Halai, at the summit of Mount Taranta, not more than eighteen geographical miles from Zulla (the ancient Adule, recently, 1860, taken possession of by the French government), near Massowah, the edge of the table-land has an absolute elevation of 8625 feet, which gives a rise of 1 in 12·7, equal to an angle of 4° 30′ with the horizon, to the eastern slope of the table-land (or, as it may be more correctly called, in Dr. Beke's opinion, broad mountain-chain of Abyssinia). The western counter-slope towards the interior of the continent has a fall of 1 in 343·7 only, giving an inclination of 10′; consequently, on a direct line from east to west along the fifteenth parallel of north-latitude, the eastern slope of the Abyssinian mountain-chain (or table-land) towards the sea is, to the western counter-slope towards the Nile, as 29 to 1. But on a line corresponding with the courses of the principal rivers from south-east to north-west, the eastern slope has a rise of 1 in 38·83, equal to an angle of 1° 41′, and the counter-slope of 1 in 460, or 7′ 30″, giving the proportion of 11·8 to 1. In making this estimate, however, the rise of the eastern slope is not taken from the level of the sea, but from that of the river Hawash, which is the recipient of the waters of the eastern slope as the Nile is of the western, and has itself an absolute elevation of 2200 feet, at a point distant from the sea about 200 miles. This, again, gives a fall of about 1 in 550, equal to an angle of 6′ 15″, for the eastward dip of the comparatively low-level country between the Hawash and the Indian ocean. "As regards the counter-slope of the Abessinian (Abyssinian) chain," Dr. Beke says, "it would seem that the fall of the land towards the Nile in the western portion of it is considerably greater than it is in the eastern; so that the surface of the table-land, or broad summit of the mountain chain, approaches more nearly to a level than if the slope were the same throughout. It is certain, however, that the table-land nowhere forms an absolute level, and that the general dip westward commences from its extreme eastern limit."

This table-land, as the same geographer has shown, may, in the most general way, be compared with those of the Indian peninsula and South America, but with this difference: the Western Ghauts in the former, and the Cordilleras of the Andes, present their principal acclivities towards the west, and thence slope gradually eastwards; whereas the African plateau rises abruptly on its eastern side, and has its western counterslope towards the interior of the continent and the valley of the Nile. Another point of difference is, that while the rivers which rise near the western edge of the Ghauts and of the Andes take their courses eastwards over the counter-slopes, at right angles with the water-parting (commonly called the water-shed) [WATER-SHED] or nearly so, and discharge their waters into the ocean—the streams which have their sources at the water-parting of eastern Africa flow in a general north-westerly direction, and fall into the Nile, which skirts the lengthened western counter-slope. To these comparisons of Dr. Beke, it may be added that the general structure of the African plateau resembles that of Tibet, described above. While the principal direction of the latter, however, is from east to west, its slopes being on the north and south—the principal direction of the former, as we have seen, is from north to south, the slopes being on the east and west. But, *mutatis mutandis*, accordingly, the resemblance between the great table-lands of Africa and Asia is closer, we think, than that of the former to the elevated country bounded by the Ghauts and the Cordilleras respectively. In this comparison the Indus and the Brahmaputra correspond to the Nile itself, while their main tributaries, the Jumna, Ganges proper, &c., answer to the streams which fall into the Nile, as already mentioned, from the south-east. The structural resemblance between the table-lands of the two great continents is also very near in another respect, allowing for the different distribution of dimensions. In the southern extension of the African plateau, the rivers flow through deep transverse valleys, forming openings through the eastern slope into the low country at its base, and thence into the ocean; just as the waters accumulated in the two great Indian rivers are discharged by openings in the Himalayan or southern slope of the Asiatic table-land, through the plains of Hindostan, into the ocean.

The African table-land, as a whole, may be described as a succession of extensive undulating plains (like the corrugations and so-called plains of Tibet, already mentioned), but dipping very gradually towards the west and north-west, and intersected by numerous streams, which, after a short course over the surface of the plateau, fall abruptly into the deep-cut fissures or valleys just noticed, in which they soon reach a depression of 3000 to 4000 feet below the general level of the table-land. In addition to the irregularities produced by these valleys, the uniformity of the surface is broken by loftier mountain-masses, which in some parts of Abyssinia attain an absolute elevation of from 11,000 to 15,000 feet. The eastern edge of the plateau itself has been clearly traced as far as the ninth parallel of north latitude, to which distance it forms the water-parting between the basins of the rivers Nile and Hawash. "How much further it extends southward," Dr. Beke remarks, "our present knowledge scarcely enables us absolutely to determine; but we may safely regard it as reaching beyond the equator." The snowy mountains observed by Captain Short, and those discovered by the missionaries Krapf and Rebmann south of the equator, appear to be connected with the broad mountain range of eastern Africa, of which the Abyssinian table-land forms the northern portion. These are the "Mountains of the Moon" of the natives and of the ancient geographer Ptolemy, which Dr. Beke has proved to be thus a meridional and not an east and west chain, in which are the sources of the Nile, and which form the eastern face of the table-land in its southern extension. The continuation of this range was crossed as far south as 7° 30′ south latitude by the recent travellers, Captains Burton and Speke. Detailed information on the whole of this subject, with maps and sections of the country, will be found in Dr. Beke's work entitled 'The Sources of the Nile,' London, 1860; from which, except as otherwise indicated, and with slight variations of description, the preceding view of the African table-land has been derived.

Plains differ not only in their elevation, but in the horizontality of their surface and general slope, and in the nature of their soil; which circumstances, together with their geographical position, influence their climate and productions, and give to the most considerable among them a particular character and physiognomy. It may be remarked that the rocky and sandy plains belong almost exclusively to the hot and temperate regions of the old world. The plains of America are generally characterised by their gramineous covering or their vast forests; the Asiatic steppes by a twofold appearance, being in some parts studded with low saline plants, and in others, as in southern Russia, Siberia, and Turkistan, covered with plants of the families of the *Compositæ* and *Leguminosæ*; while the greater part of the European plains are richly cultivated.

We say such are the general characteristics, for there are plains of similar character and physiognomy in very different and widely separated regions of the world. The high land of the Campos Parexis, for instance, in South America, is very similar in physiognomy to the desert of Gobi in Asia. The *Desiertos*, near Coquimbo, are of the same character as the Sahara. The *Puszta* of Hungary resemble the savannas of the New World; and the pampas of Cordova are not unlike some of the Siberian steppes.

Though, as we have said, plains constitute by far the greater portion of the earth's surface, and are very varied in their appearance, there are nevertheless some which are remarkable not only for their extent, but for the peculiarities which distinguish them; peculiarities derived, no doubt, in part, from the circumstances attending their original formation, and which no subsequent causes have been able to obliterate. These remarkable plains are known under the names of deserts, landes and heaths, steppes, savannas and prairiès, llanos, pampas, and selvas (or forest plains) of the Marañon. DESERTS having been already described under their particular head, we shall here give a brief account of the others.

Heaths and Landes of Europe.—From Paris to Moscow and Cazan on the one hand, and to Astrakan on the other, is one continued plain, comprising the lowlands of Northern France, the Netherlands, the North of Germany, the whole of Prussia, and the greater part of Poland and Russia, as far as the first terraces of the Ural. Besides which there are many minor plains, as those of Wallachia and Bulgaria, Hungary, Lombardy, &c. The ancient civilisation of Europe has covered the greater part of its plains with cultivation and rendered some of these lands the richest in the world (the plains of Lombardy); nevertheless there are some spots which seem to defy all human efforts to bring them into cultivation; such are those between the Lower Volga and the Ural, of which we shall speak more fully in describing the steppes, and such are the heaths and landes. Of these, next to those of Russia, the most extensive are in Lapland and west Gothland. But the chief landes and heaths, properly so called, lie in the north-west of Germany. In Lower Silesia, Lusatia, and Brandenburg, there is little else than sand, and also in Pomerania and Mecklenburg, studded with a few hills, numerous lakes, and, along the maritime parts of the latter, having some woods of oak. In Hanover the gentle acclivities are covered with heath, which extends through part of Holstein to the centre of Jutland. The most sterile parts of Hanover however are the landes of Lüneburg and Verden between the Elbe and the Weser, and those of Meppen on the right bank of the Ems. Those of Lüneburg and its vicinity are said to cover a space of about 6000 square miles. These landes are covered with heath, with pine woods, and marshes. On the west of the Ems, about Bentheim, there are also extensive landes covered with swamps and stagnant pools. In the province of the Lower Rhine, in the environs of Monjoie, between Eupen and Malmedy, we again find vast landes coated with heath. In France, of which country about one-twelfth is unproductive soil, there are extensive landes and barren spots. That tract which extends eastward from the right bank of the Adour, and gives its name to the department, consists almost wholly of pools, marshes, and heath, and this sterile plain extends a great way into the department of the Gironde. The shingle plain of Crau, in the department of the Bouches du Rhone, is well known, and likewise the sterile chalky plain of La Champagne Pouilleuse. In the kingdom of Naples there are considerable landes.

Steppes.—This name, which is Russian, is given more particularly to the extensive plains which lie on the north-west of Asia. Considered as a whole, the steppes have a character quite different from the other great plains of the world, though in different parts they present partially the distinguishing features which characterise the llanos, the savannas, the pampas, the sandy deserts, &c. Generally speaking, they consist of rich pastures intermingled with woods, barren sands, muriatiferous clay, and abounding in lakes, pools, and streams of salt and bitter waters.

From the sea of Azof on the west to the foot of the Little Altaï on the east, there is a band extending, in a north-east direction, from the mouth of the Kuban towards Torusk, where the undulations of the plain prevent the egress of the waters, which, percolating through a highly saline soil, are collected in the hollows into innumerable lakes and pools of salt water, which give a peculiar feature and interest to these steppes.

Farther northward, the Siberian plains have a general slope towards the Frozen Ocean, and are intersected by the great rivers Obi, Yenisei, and Lena; between the lower courses of which extend immense frozen marshes, covered with moss, and interspersed with a few sandy and clayey hills crowned with tufts or clumps of stunted birch and other dwarf shrubs.

The greater part of what are properly called the steppes form a considerable part of the country known as Independent Tartary, which is inhabited by the nomadic hordes of the Kirghis Cossaks.

The steppe which lies on the north-west of the Caspian, bounded by the Caucasus, the sea of Azof, the lower course of the Don, and thence to the Ural or Iaïk, is inhabited by the Cossaks of the Black Sea and the Nogay Tartars. The whole of this steppe is characterised as composed of hills of a moving shelly sand, between which are beautiful green pastures, and marshy hollows with reeds and clumps of trees, among which are willows, poplars, and the wild olive. There are numerous salt streams and brine pools, barren patches covered with a saline efflorescence, and in many places tufts of saline plants. The fertility of the hollows seems due to a sheet of water which, coming from the hilly range called Obstcheï Sirt, a branch of the Ural, flows immediately below the sandy surface, being probably retained by an impervious substratum.

Between the Iaïk on the west and a low ridge of hills on the east, which may be regarded as a south-eastern continuation of the Ural, and which extends between the Aral and the Caspian, is another steppe similar in character to that already described. It is occupied by the Kirghis of the little horde; while what is called the central or middle horde ranges over the vast steppe contained between the lake Aral and the Sir on the south, the low hills already mentioned on the west, the Ouloustaou and Naourgiuskaia ranges on the north, and the Sarasou on the east. With the exception of the Sir, all the waters of this great basin lose themselves in the sand, or in lakes more or less salt, the principal of which is the famous Aksakal Bari.

To the north of the last-mentioned steppe lies the great steppe or plain of Ischim, which extends from the eastern slope of the southern extremity of the Ural, across the Tobol, to the Irtish. It takes its name from the river Ischim, which, dividing it nearly in two, falls into the Irtish near Petropavloffskoï. The north-east part of this steppe towards Tara, on the left bank of the Irtish, is covered with dense forests abounding in game and rich in firs.

Crossing the Irtish, we enter the great steppe of Baraba, occupying all the space between that river and the Upper Obi. This steppe, lying nearer the foot of the mountainous district of the south and east, contains numerous lakes and pools, particularly in its southern portion. This district is in many places extremely fertile, and along the water-courses the grass grows luxuriantly. The north and north-west parts are wooded, but the more southern, those lying along the Irtish and towards the Altaï, have few trees, and are less fertile. The lake Tschany, the largest and nearly the most northerly of the great group of lakes, abounds in fish; the surrounding country is extremely fertile, and abounds in aquatic game, the chief nourishment of the Tartar tribes who live dispersed along the frontiers of this canton. Interspersed with the sandy, barren, and saline spots, are many places where there is excellent land for tillage, in which grain and flax succeed well. The Kirghis of the great horde occupy a more mountainous country to the south of the Sarasou.

Besides these great steppes, there are numerous other patches of greater or less extent and similar general character in Central Siberia, reaching from the Ural to the Lena.

Previous to the subjection of the wandering hordes to Russia, that country had lines of fortified posts for its protection against these predatory bands; but now that the different hordes of Kirghis acknowledge the supremacy of Russia, and their several chiefs are paid by the Russian government, many of these posts have been abandoned, and open villages are now multiplying along the roads by which the Russian caravans travel towards Kiachta and in the direction of the mining districts of the Altaï. The inhabitants of these villages, some of which are very large, are the only stationary population of the steppes. The wandering tribes are very numerous, and are continually shifting their ground to find food for their numerous cattle, consisting of horses, camels, horned cattle, sheep, and goats.

The extent of the steppes properly so called, excluding the marshy plains of the north, may be about 1,000,000 square miles.

Savannas or Prairies.—The central part of North America, from the Frozen Ocean to the Gulf of Mexico, may be regarded as one continuous plain, divided by a low water-parting into the north-eastern basin, whose waters flow into the Polar Sea, Hudson's Bay, and, by the great lakes and St. Lawrence, into the Atlantic, and the basin of the Missouri and Mississippi whose waters fall into the Gulf of Mexico.

This immense tract of country, estimated by Humboldt at 2,430,000 square miles, is extremely varied in climate, in character and productions; for while the northern portion which is watered by the Mackenzie, Back's River, the Churchill, and the Saskatchewan, is condemned for the greater part of the year to all the horrors of an iron-bound soil and stunted polar vegetation, palms and other tropical trees grow at the extremity of the southern portion. It is this southern basin, watered by the mighty Missouri and Mississippi, with their abundant affluents, that contains those extensive grass-covered tracts, the savannas and prairies. They lie chiefly on the western side of the Mississippi, though along the Illinois river they are found to the extent of 1,200,000 acres, and also in other parts of the basin east of the Mississippi. But the whole of the territory from the right bank of the Mississippi to the mountains is not one continued savanna, or even an unbroken horizontal plain; for it rises towards the mountains, many of whose spurs are reached by the Missouri, which has eroded their extremities into bluffs. These ridges form the boundaries of the basins of the great tributary streams, the Platte, the Kansas, the Osage, the Arkansas, &c. Woods are also occasionally met with along the Mississippi and other watercourses, as likewise in Arkansas; and in some places, as between the Platte and the Missouri, there are extensive surfaces of moving sands resembling those of the African desert. Elsewhere again, as from the mouth of the Arkansas along the Mississippi, a distance of 450 miles long and 40 miles broad, the soil is all swamps and pools, with abundance of trees: this is also the case above Illinois lake and elsewhere. Along the upper Missouri, from the territory of the Mandans, is an interminable plain without trees or shrubs except in the marshy spots. In various parts, but more especially along the borders of the great plain, and in Arkansas, salt is found.

The savannas, or prairies, as they are also called, are divided by Flint, an American writer, into three kinds :—1, the heathy or bushy, which have springs and are covered with small shrubs, grape-vines, &c.; very common in Indiana, Illinois, and Missouri; 2, dry or rolling (a designation which will be explained in the sequel), generally destitute of water and almost of all vegetation but grass; they are the most common and extensive: the traveller may wander for days in these vast and nearly level plains without wood or water, and see no object rising above the horizon; 3, the alluvial or wet prairies, the smallest division; they are covered with a rich vegetation of tall rank grass. The soil is deep, black, friable, and fertile, and abounding in pools without issue, left by the floodings of the rainy season. It is over the second kind chiefly that the bisons wander in herds of from 40,000 to 50,000. Stags, or more properly wapitis, are also very numerous; and between the Arkansas and Red rivers there are droves of wild horses. Deer are also numerous; and along the borders of the Missouri, above the Platte, or shallow river, the antelope abounds in herds of several hundreds. In summer wild goats are seen in vast numbers along the Mississippi. Above the Mandan villages are grizzly bears; and badgers, beavers, otters, foxes, wolves, racoons, opossums, squirrels, porcupines, and skunks inhabit the same region. To this enumeration of Warden's and Flint's, Lyell adds the jaguar. The waters teem with alligators and tortoises, and their surface is covered with millions of migratory water-fowl, which perform their annual voyage between the Canadian lakes and the shores of the Mexican Gulf.

Precise information on the extent and peculiar characters of the Prairies, obtained in an elaborate survey, has recently been given by Mr. James Hall, state geologist of Iowa, a man of science advantageously known to English geologists. This is introduced in an account of the physical geography of that region, forming Chapter I. of Mr. Hall's 'Report on the Geological Survey of the State of Iowa,' published by authority of the legislature of that state, 1858. It involves many particulars having an important bearing on the structure of the plains of North America in general, and with some slight omissions we shall now transfer it to our columns. Fortunately for the investigation of this subject, the state of Iowa consists, mainly, of prairie country.

The prairie region of the west occupies a vast extent of country, extending over the eastern part of the Ohio, Indiana, the southern portion of Michigan, the southern part of Wisconsin, nearly the whole of the states of Illinois and Iowa, and the northern portion of Missouri, and gradually passing, in the territories of Kansas and Nebraska, into the arid and desert region which lies at the base of the Rocky Mountains, called—in that local technicality which is so characteristic of America, and which, in every part of the world appears to have preceded scientific geographical description—*the Plains*. This passage takes place in the region between the parallels of 97° and 100°, west of which belt the country becomes too barren to be inhabited and worthless for cultivation. The passage from the heavily wooded region of the north and east into the treeless plains of the west is a gradual one, and the disappearance of the underwood and the predominance of "oak openings," or groves of oak and other forest trees, not crowded together, but scattered over the surface at a considerable distance from one another, without any low shrubs or underbrush between them, is the characteristic of the border of the prairie region. To one coming from the dense thickets of low and tangled shrubs which choke the forests of the north, and render travelling through them difficult, even to the pedestrian, the open woods of the north-west offer a striking contrast to that which has been left behind, and form a natural introduction to the grassy plains or prairies.

The elevation of the prairie region above the level of the sea gradually increases from the east to the west. The lower part of Illinois varies from 100 to 250 feet above the river at Cairo, or 400 to 550 feet above the sea-level. In the central portions of the state the levellings along the line of the Illinois central railroad, indicate an average elevation of from 650 to 750 feet, which increases towards the northern boundary to 800 or 900 feet above the sea. Some of the highest swells of the prairie attain an elevation of nearly 1000 feet. The more elevated portions of Southern Wisconsin are about 1100 feet above tide-water. The region from the Mississippi westward is a gradually ascending plain as far as the very base of the Rocky Mountains. Within the limits of Iowa the table-land along the water-parting between the streams flowing into the Mississippi and the Missouri, the "Plateau du Coteau des Prairies" of Nicollet, attains the altitude of from 1400 to 1500 feet above the sea; and to the west of the Missouri the ascent still continues, the soil being more and more arid, until at the 105th meridian, an elevation of 5000 feet is attained.

The prairie is designated as "flat" or "rolling," its surface in the one case being nearly level, and in the other gently undulating. The flat prairie is found chiefly south and west of Lake Michigan, on the head-waters of the Illinois and Wabash rivers. In other districts the rolling prairie greatly predominates over the flat, especially in Iowa, where there are but few tracts of any extent which are not more or less undulating. Even in the rolling prairie the irregularities of the surface are but trifling in amount, compared with the vast extent which can be taken in at one view: so that it often happens that a region which, seen from a distance, appears to be almost a dead level, is, in reality, furrowed by broad depressions, which give a wave-like character to its surface. Thus, the traveller crossing the prairie in any direction except along its water-parting, will be surprised to find himself constantly ascending and descending, although only hills of moderate elevation. The depth of these depressions below the mean level of the prairie may frequently be as much as 50 feet; but it does not often greatly exceed that amount, without the drainage becoming sufficient to convert the water, which collects in them, into a running stream. The "swales," or "sloughs," of the prairie, as these depressions are called, are wet and marshy except in the dry seasons, and, in the spring and autumn make the roads almost impassable.

The prairies are covered with a dense vegetation of grass and herbaceous plants, to the almost entire exclusion of trees, which occur only under peculiar circumstances of moisture and soil, in scattered groups called groves, or along the larger streams, or, occasionally, on low rocky ridges which are sometimes met with. This growth of timber in the river bottoms does not entirely disappear until we reach the border of the "plains," in the longitude of about 98° west of Greenwich. In the swales or depressions, which are comparatively humid, the grass grows very tall and rank; and the higher and drier the prairie the finer its growth, and more dense and closely interwoven the sod. Among the grasses of the prairies is interspersed a great variety of flowering plants, which bloom in constant succession from spring to autumn, and lend a peculiar charm to the landscape, giving beauty and variety to what might otherwise be called a monotonous scene. The characteristic herbs of the prairies would seem to be compositæ, especially *Helianthoid Compositæ*, according to Dr. Asa Gray, who has enumerated the principal species in the 'American Journal of Science,' Series II., vol xxiii. p. 397.

The upper portion of the material constituting the superficial covering of the prairie is always finely comminuted, and usually has few loose boulders or fragments of rock scattered through it, although they sometimes lie upon the surface in isolated groups, or singly. Upon the great prairies in Central Iowa, one may frequently travel over a large extent of surface without seeing a single stone, not even so much as the smallest pebble. In the swales, and in some of the bottom lands, especially in the southern part of the State, the rich black vegetable mould is very deep, but on the prairies it is usually from one to two feet. The subsoil is almost invariably a quite argillaceous loam, and there is a gradual passage downwards into a material in which, though containing sandy portions and occasional pebbles, the argillaceous element greatly predominates.

The material of the superficial covering of the prairie has evidently not been transported to any great distance. It bears the marks of having had its origin chiefly in the decomposition of the rocks which underlie it, and in fact, the prairies are exclusively confined to regions underlaid by soft sedimentary strata, especially shales and impure limestones. It would be difficult to imagine, Mr. Hall remarks, a prairie soil existing on crystalline rocks.

After describing the prairies, Mr. Hall proceeds to discuss, as follows, the difficult and contested problem of their origin, and of the cause of the absence of trees over so extensive a region :—

"The idea is very extensively entertained, throughout the west, that the prairies were once covered with timber; but that this has been destroyed by the fires which the Indians have been in the habit of starting in the dry grass, and which sweep over a vast extent of surface every autumn. A few considerations will show that this theory is entirely untenable.

"In the first place, the prairies have been in existence at least as far back as we have any knowledge of the country; since the first explorers of the west described them just as they now are. There may be limited areas once covered with woods, and now bare; but, in general, the prairie region occupies the same surface which it did when first visited by the white man.

"But, again, the prairies are limited to a peculiar region, one marked by certain characteristic topographical and geological features, and they are by no means distributed about wherever the Indians have roamed and used fire. Had the frequent occurrence of fires in the woods been the means of removing the timber and covering the soil with a dense growth of grass, there is no reason why prairies should not exist in the eastern and middle states as well as in the western. The whole northern portion of the United States was once inhabited by tribes differing but little from each other in their manner of living.

"Again, were the prairies formerly covered by forest trees we should probably now find some remains of them buried beneath the soil, or other indications of their having formerly existed. Such is not the case, for the occurrence of fragments of wood beneath the prairie surface is quite rare; and when they are found, it is in such a position as to show that they have been removed to some distance from their place of growth.

"It has been maintained by some, that the want of sufficient moisture in the air or soil was the cause of the absence of forests in the north-west; and it is indeed true that the prairie region does continue westward, and become merged in the arid plains which extend along the base of the Rocky Mountains, where the extreme dryness is undoubtedly the principal obstacle to the growth of anything but a few shrubs, peculiarly adapted to the conditions of the climate and soil which prevail in that region. This, however, cannot be the case in the region east of the Mississippi and near Lake Michigan, where the prairies occupy so large a surface; since the results of meteorological observations show no lack of moisture in that district, the annual precipitation being fully equal to what it is in the well-wooded country farther east in the same latitude. Besides, the growth of forest trees is rich and abundant all through the prairie region, under certain conditions of soil and position, showing that their range is not limited by any general climatological cause.

"Taking into consideration all the circumstances under which the peculiar vegetation of the prairie occurs, we are disposed to consider the nature of the soil as the prime cause of the absence of forests and the predominance of the grasses over this widely extended region. And although chemical composition may not be without influence in bringing about this result, which is a question for farther investigation, and one worthy of careful examination, yet we conceive that the extreme fineness of the particles of which the prairie soil is composed is probably the principal reason why it is better adapted to the growth of its peculiar vegetation, than to the development of forests. It cannot fail to strike the careful observer that where the prairie occupies the surface, the soil and superficial material have been so finely comminuted as to be almost in the state of an impalpable powder. This is due partly to the peculiar nature of the underlying rocks and the facility with which they undergo complete decomposition, and partly to the mechanical causes which have acted during and since the accumulation of the sedimentary matter forming the prairie soil.

"If we go to a thickly-wooded region, like that of the northern peninsula of Michigan, and examine those portions of the surface which have not been invaded by the forest, we shall observe that the beds of ancient lakes, which have been filled up by the slowest possible accumulation of detrital matter, and are now perfectly dry, remain as natural prairies, and are not trespassed on by the surrounding woods. We can conceive of no other reason for this than the extreme fineness of the soil which occupies these basins, and which is the natural result of the slow and quiet mode in which they have been filled up. The sides of these depressions, which were once lakes, slope very gradually upwards; and being covered with a thick growth of vegetation, the material brought into them must have been of the finest possible kind, as is proved to have been the case by examination. Consequently, when the former lake has become entirely filled up and raised above the level of overflow, we find it covered with a most luxuriant crop of grass, forming the natural meadows from which the first settlers are supplied with their winter store of fodder."

The philosophical geologist may with advantage compare this part of Mr. Hall's statement and reasoning with those of Mr. G. Poulett Scrope and Sir C. Lyell respecting the formation of the Limagne d'Auvergne, or valley of the Allier, which was once the largest of three or four freshwater lakes existing in the miocene or middle division of the Tertiary period, in the country which is now Central France. The deposition of the fine lacustrine sediment which constitutes the marls and a part of the limestone of the Limagne, in an age characterised by numerous extinct mammals and reptiles, offers a curious parallel to that of the corresponding sediment of the ancient American lakes, forming the soil of the prairie basins, as described by Mr. Hall, at a much later period of the earth's history, one which may be said almost to connect the present with the latest pre-historic era. Nothing can be more different than the present geographical configuration and aspect and geological structure, of the two regions; but the illustration which the comparison affords of the identity of geological causes in all periods, is most interesting and instructive. It suggests also the inquiry whether evidence can be obtained that at any epoch in the process of filling up of the basins of the ancient lakes of Auvergne, and formation of similar lacustrine plains in other parts of the world, the *prairie* condition intervened. The discovery of organic remains indicating the former existence of the peculiar prairie soil and vegetation would of course afford that evidence. In North America itself it would be equally important to ascertain whether any pleiocene or pleistocene formations present similar evidence of ancient prairies. See Scrope's 'Geology and Extinct Volcanos of Central France,' ch. ii., and Hall's 'Report,' cited above.

"Applying these facts," Mr. Hall continues, "to the case of the prairies of larger dimensions farther south, we infer, on what seem to be reasonable grounds, that the whole region now occupied by the prairies of the north-west was once an immense lake, in whose basin sediment of almost impalpable fineness gradually accumulated: . . . . that this basin was drained by the elevation of the whole region; but, at first, so slowly, that the finer particles of the superficial deposits were not washed away, but allowed to remain where they were originally deposited. After the more elevated portions of the former basin had been laid bare, the drainage becoming concentrated in comparatively narrow channels, the current thus produced, aided perhaps by a more rapid rise of the region, acquired sufficient velocity to wear down through the finer material on the surface, wash away a portion of it altogether, and mix the rest so effectually with the underlying drift materials, or with abraded fragments of the rocks in place, as to give rise to a different character of soil in the valleys from that of the elevated land. This valley soil, being much less homogeneous in its composition and containing a larger proportion of coarse material than that of the uplands, seems to have been adapted to the growth of forest vegetation; and, in consequence of this, we find such localities covered with an abundant growth of timber.

"Wherever there has been a variation from the usual conditions of soil, on the prairie or in the river bottom, there is a corresponding change in the character of the vegetation. Thus, on the prairie, we sometimes meet with ridges of coarse material, apparently deposits of drift, on which, from some local cause, there has never been an accumulation of fine sediment: in such localities we invariably find a growth of timber. This is the origin of the groves scattered over the prairies, for whose isolated position and peculiar circumstances of growth we are unable to account in any other way.

"The condition of things in the river valleys themselves seems to add to the plausibility of this theory. In the district which we have more particularly examined, we have found that where the rivers have worn deep and comparatively narrow valleys bordered by precipitous bluffs, there is almost always a growth of forest; but where the valley widens out, and the bluffs become less conspicuous, indicating a less rapid erosion and currents of diminished strength, there deposition has taken place under circumstances favourable to the accumulation of a prairie soil, and the result has been the formation of the 'bottom prairie,' which becomes so important a feature of the valleys of the Mississippi and Missouri below the limits of Iowa. Where these bottom prairies have become, by any recent change in the course of the river currents, covered with coarser materials, a growth of forest trees may be observed springing up, and indicating by their rapid development the presence of a congenial soil."

Llanos.—The whole interior of South America, from the mountains of Caracas on the north to the Straits of Magalhaens on the south, is divided by comparatively low transverse ridges, running east and west into three great basins; that of the Orinoco on the north, that of the Amazon or Marañon in the centre, and that of the La Plata on the south. The first comprises the llanos, vast plains occupying a surface of 260,000 square miles. They may be divided into two principal portions: the first, beginning at the mouths of the Orinoco, extends westward as far as the Andes of New Granada, being bounded on the north by the Caracas, and on the south by the mountainous group of Parimé and the Rio Apure, an affluent of the lower Orinoco. The other portion of the llanos, which is twice as extensive as the first, reaches from the Apure on the north to the Caqueta (an affluent of the Marañon) on the south: having the Andes on the west, and the sierra of Parimé and the Orinoco on the east. The inclination of these plains is to the east and south, and they are traversed by many streams, which, taking their rise from the eastern slope of the Andes, bear their tributary waters to the Orinoco. As the medium height of the llanos does not exceed 200 feet, the course of the rivers is very slow and often scarcely perceptible.

The chief characteristic of the llanos, says Humboldt, is the absolute want of hills and inequalities, the perfect level of every part of the soil. Often in the space of 270 square miles there is not an eminence of a foot high. This resemblance to the surface of the sea strikes the imagination most powerfully where the plains are altogether destitute of palm-trees, and where the mountains of the shore and of the Orinoco are so distant that they cannot be seen. This unvarying equality of surface reigns without interruption from the mouths of the Orinoco to the Villa de Aurore and Ospinos under a parallel of 540 miles in length, and from San Carlos to the Caqueta, on a meridian of 600 miles.

There are however, notwithstanding this uniformity of surface, two kinds of inequalities in the llanos. The first, called *brancos*, are horizontal banks of sandstone or limestone standing four or five feet higher than the rest of the plain, and sometimes many leagues in length. The second kind of inequality, called *mesa*, consists of convex eminences rising to the height of a few fathoms.

The llanos have different names in different parts: thus, from the Mouth of the Dragon, the llanos of Cumanà, of Barcelona, and of Caracas or Venezuela, follow from east to west, when, turning southward from 8° N. lat., between the meridians of 67° 40′ and 70° 40′, we find the llanos of Varinas, Casuare, the Meta, Guaviare, Caguan, and Caqueta. All these are again subdivided.

The aspect of the llanos is somewhat dissimilar in different places: but the greatest difference depends upon the seasons. The local dissimilarity arises chiefly from the nature of the palm-trees scattered about, which vary in different places, and also from the greater or less abundance and variety of the dicotyledonous plants which are intermixed with the grasses, the height of which latter is also very unequal, being sometimes only a few inches at a distance from the watercourses, and rising to a height of four feet in their vicinity. In this high grass the jaguar, or American tiger, lurks to spring upon the mules and horses that cross the plain. But the season of drought or of rain entirely changes the aspect of the greater part of the llanos. In the rainy season, says Humboldt, the llanos display a beautiful verdure, but in the time of great drought they assume the aspect of a desert. The grass is then reduced to powder, the earth cracks, the alligators and great serpents remain buried in the dried mud, till awakened from their long lethargy by the first showers of spring. These phenomena are observed on barren tracts of fifty or sixty leagues in length where the llanos are not traversed by rivers.

The principal and almost the only trees of the llanos are different varieties of palms. The *Corypha tectorum*, or Palma de Cobija, solitary or in clumps, rises here and there as a landmark through these trackless plains. It is chiefly found in the llanos of Caracas from Mesa de Peja, as far as Guayaval. Farther north and north-west, near Guavare and San Carlos, its place is taken by another species of the same genus. Other palm-trees appear to the south of Guayával, especially the *Piritu*, with pinnate leaves, and the *Murichi*, whose beautiful verdure, at the period of the greatest drought, contrasts with the mournful aspect of the grey and dusty leaves of the cobija. Two or three other species of trees besides palms are also found in the llanos, and it is round these clumps that the llanos are the most fertile.

The great wealth of the llanos consists in the numerous herds which they feed. The first horned cattle were let loose in these extentive pastures by Christoval Rodriguez, about the year 1548, since which time they have increased to almost countless numbers. About 98,000 head of cattle are said to wander in the pastures round Calaboza. But, according to M. Depons, there are, from the mouths of the Orinoco to the lake of Maracaybo, 1,200,000 oxen, 180,000 horses, and 90,000 mules, the annual produce of which herds is estimated at about 5,000,000 francs. But these estimates were made many years since, and are scarcely applicable to the present time.

All the parts of the llanos are not equally favourable for the breeding of mules and oxen; but in some of those places, where the herds are less numerous, the pastures are so fertile as to furnish meat of an excellent quality for provisioning the coast.

The horses of the llanos are not very large, but are descended from a fine Spanish breed. Deer are natives of these plains.

The greatest curiosity of the llanos are the gymnoti, or electrical eels, which live in the pools as well as in the rivers of this part of South America.

We may also mention, as distinguishing the llanos from the pampas, and from the plains of North America, the Sahara, and the steppes of Asia, the total absence of any formation of chloride of sodium or common salt.

Pampas, from an Indian word, which, in the Quichua language, signifies properly a flat, is the name given to extensive plains in the southern and central parts of South America. Those which lie to the south and north-west of Buenos Ayres are called, the former the Pampas of Buenos Ayres, or simply the Pampas, and the latter the Pampas of Cordova. The plains to the south of the province of Chiquitos bear the name of the Pampas de Huanacos. There is also one more to the north, between the river Beni and the river Marmore, a tributary of the Madeira; and lastly, to the north between Huallaga and the Ucayal there is another, called the Pampas del Sacramento.

The Pampas of Buenos Ayres are bordered on the west by the forests which lie along the base of the Andes of Chile; on the east by the Atlantic; on the south by the Rio Negro and Patagonia, the interior of which, though little known, seems to be of the same nature with the pampa itself; and on the north-east by the Rio de la Plata. In the direction due north the pampa narrows between the Parana and a ridge coming from the Andes, called the Sierra de Cordova.

This region, reckoning to the foot of the mountains on the west, occupies a surface of about 315,000 square miles. This plain has no general slope, or rather it slopes so gently towards the east, that the slightest inequalities, together with the absorbing nature of the soil and the great evaporation, are sufficient to arrest the course of the waters; so that, with the exception of the rivers Colorado and Negro, which come from the Cordilleras, and which traverse the southern part of the pampas, and the Salado, a small stream which flows into the Rio de la Plata at its mouth, the pampas have no running waters, but, instead of them, a great many shallow pools, of which the water is often brackish. There is one at about 450 miles from Buenos Ayres, in the direction west-south-west, always filled with salt, from which the city of Buenos Ayres was yearly supplied before the port was thrown open to foreigners. The southern part of the pampas is sandy, with patches of saline plants and stunted trees; the northern parts are covered with grass, supplying food to large herds of cattle and wild horses, the descendants of those first introduced by the Spaniards. It has been said that several million head of cattle and about half as many horses feed on the pampas of Buenos Ayres. There are also wild beasts.

This plain is traversed by a road which leads from Buenos Ayres to Chile, along which the traveller meets with huts, which form stations, distant from each other about seven or eight leagues. The journey may be made on horseback or in a carriage, but it is sometimes dangerous, on account of the Indians.

The pampa of Cordova extends from the right bank of the lower Parana to the Sierra de Cordova at the west. On the north it joins the sandy plains or *travesia* of Santiago del Estero.

This pampa resembles that already described in all things, excepting being traversed by a greater number of streams. All these streams, however, with the exception of the Rio Salado, which falls into the Parana, lose themselves in the sands, or end in marshes and lakes without issue, and which in the country are called *Lagunas*. Such is particularly the case with the Rio Dulce, which, rising in a fertile valley on the eastern slope of one of the lateral chains of the Andes, passes by S. Miguel de Tucuman and Santiago, and finally empties itself into the Lagunas de las Porongos; the same is also the case with the Rio Primero, on which is situated Cordova, the best of all the towns of Tucuman, and where the Jesuits had formerly a celebrated university.

Throughout the whole of the country between the Parana and the mountains to the west, from Chaco on the north to the extreme southern extremity of the Pampa of Buenos Ayres, there is neither river, lake, nor well that is not brackish, saline, or alkaline. Even the Pilcomayo and the Vermejo partake of this saltness; and Azara assures us that he has seen in lagunas, dried up by the heat, a layer of Epsom salts above three inches in thickness. Nitron, sulphate of soda, and glauberite also occur in the lagunas.

The inhabitants of the fertile valleys lying to the west and north of the plains of Tucuman, similar in some respects to Little Bucharia, rich in their flocks, without ambition, and without care, close the day in rural amusements worthy of being sung by Theocritus and Virgil. It is nevertheless true that there are spaces of many square leagues in extent condemned to absolute sterility. The traveller may pass for days together over sands and stones, between which there spring up here and there some saline plants, without meeting with any other objects than a few isolated huts on the borders of some brackish stream; these barren districts are generally designated by the term *travesia*.

Pampa of Huanacos.—Leaving the pampa of Cordova on the south, and travelling through forests swarming with bees, which extend beyond the Rio Dulce and the Salado, we enter on the territory of the Abipones, a race of very warlike Indians; after which, crossing the Rio Vermejo, we gain the plains of the Gran Chaco, occupied by more or less savage indigenous tribes. This region is traversed by the Rio Pilcomayo, which, passing near the mines of Potosi, falls into the Paraguay below the city of Assumption. To the north lies the Pampa de Huanacos, adjoining the province of Chiquitos, bounded on the east by the great laguna of Xarayes, through which passes the frontier of Brazil; on the west by the heights of Santa Cruz de Sierra, and on the north by the forests of the province of Moxos and the sandy plateau called Campos Parexis.

Pampa de Moxos is on the north of the province of Moxos, between the rivers Beni and Marmoré; and between the junction of this latter and the Guapore, another source of the Madeira, are other pampas of considerable extent.

Pampa del Sacramento.—This pampa is situated on the north-west of Cuzco. It differs from the other pampas in having a more tropical vegetation, and in its soil not being saline. It occupies a surface of from 54,000 to 63,000 square miles.

Such are the principal pampas of South America; and, if we include a part of Patagonia as being of the same nature with the pampas, we shall have, without reckoning the pampas of Moxos and Sacramento, and a number of spots of similar character but less extent, an almost uninterrupted band, extending from the Campos Parexis, in latitude 15° S., to the bay of St. George in 45°, or about 2800 geographical miles long and 300 wide, or a surface of 840,000 square miles of plain, partly sand, and partly marshy and saline, and producing hardly anything but pasture and a few stunted trees. Humboldt estimates the whole of the pampas of Rio de la Plata and Patagonia at 135,200 square leagues of 20 to the degree.

The *Selvas*, or forest-covered plain of the Marañon.—Independent of the vast forests which cover great part of the plains of North America, particularly on the east of the Mississippi, there is the immense plain of the Marañon in South America, extending over a surface of 2,340,000 square miles, of which about 719,000 are covered with primeval forests, the rest of the space being occupied by the waters, and by open patches of a character similar to the llanos and savannas, though little known. We merely mention this region here as one of the most extensive continuous plains in the world.

If the great plains we have described owe their peculiar character to climate and situation, a very little reflection will suffice to show the immense influence which they in their turn must exercise over the climate of the regions contiguous to them, and the great modifications they must effect on mere solar temperature. Indeed the curves of the isothermal lines sufficiently prove that the several climates of the earth depend on the joint action of solar radiation, and the magnitude, distribution, conformation, soil, and productions of the solid parts of the globe, and the extent and relative position of the great bodies of water by which they are surrounded. Nor have the vast plains of Asia and America performed a less important part in the moral history of mankind, whether as having favoured or opposed the emigrations of nations and the progress of civilisation.

PLAN. This word (which is the same as Plane) means a representation of a plane section of any building, country, &c. Usually it is to the horizontal section that the term is applied, the words section or elevation being used to signify the vertical plans. A map is not properly a plan, but a PROJECTION, unless the country represented be perfectly level: nevertheless the term is commonly applied to maps of very small portions of a country, as an estate or a town.

PLANE, PLANE-ANGLE. [STRAIGHT LINE AND PLANE.]

PLANE, INCLINED. [INCLINED PLANE.]

PLANE OF POLARIZATION. [POLARIZATION.]

PLANET (ἀστὴρ πλανήτης, a wandering star), **PLANETARY**

THEORY, MOTIONS, PERTURBATIONS, INEQUALITY, &c. The term planet was first used as one of distinction between the stars which preserve their places, or seem to do so, and those which have a sensible motion, and, as is now known, about the sun. The etymology would oblige us to include comets—many of the stars, which have small motions of their own, or proper motions, as they are called—all those double stars which revolve about each other—and all the satellites which revolve about other planets. As discovery proceeds, it is likely that every body in the universe will be found to be planetary. The word however has changed its meaning, and is used to stand for a heavenly body which makes successive revolutions about our sun. It thus includes—the old planets, Mercury, Venus, Mars, Jupiter, Saturn (excluding the sun and the moon, the most easily discovered planets of all)—the planet of Copernicus and Galileo, on which we live—the new planets or Asteroids, of which there are now (November, 1860) sixty-two; and the periodic comets of Halley, Encke, Biela, Brorsen, D'Arrest, and probably many others.

The plan of this work leaves us little to say under so general a term as Planet, and that little consists mostly of references, and explanations of isolated points. The order of discoveries connected with the subject, so far as it is matter of history, must be looked for under Astronomy. It is impossible to separate the history of one part of astronomy from that of another: the fixed stars, on which all celestial measurements depend, must accompany the planets in every account of the latter; the mathematical and physical considerations which give rise to our power of predicting the motions and places of the planets, apply equally to those of the moon and comets.

By a Planetary Theory was once meant any hypothesis which serves to explain the motions of a planet, as actually perceived. Thus there was one theory of Mercury, another of Venus, &c., each (without connection with the rest) expounding the nature and magnitude of all the suppositions which must be superadded to that of the simple circular motion round the sun, in order to enable the theorist to predict the planet's place at any given future time. At present, by the theory of a planet is meant the deduction of its motion from the theory of gravitation. Given the places of all the bodies of the solar system at any one moment, together with their velocities and the directions of their motions, the assumptions of the theory of gravitation are found sufficient to deduce tables which almost rival observation itself in the accuracy with which predictions can be made; for an instance, see Moon. When tables are constructed with such fundamental data only, they are called *theoretical:* but if some of those details which should have been deduced from the theory of gravitation have been deduced from observation, the tables are then partly *empirical.* For the treatment of the theory of gravitation as a question of physics, see Attraction: for the deduction of the character of the main inequalities of the planetary motions, and most points connected with the detailed results of that theory, see Gravitation: for the results which are particularly connected with the secular inequalities, and the reasons which we have to infer the permanence of the whole system, unless acted on by some new and external cause, see Solar System. See also the general considerations under the word Theory.

The Planetary Theory, it must be remembered, in the sense in which those words are now understood, explains only the motions of the planets round the sun. A spectator situated on the last-named body would find it sufficient to predict the place among the stars, of every planet at every time: or a terrestrial astronomer might assign by it the places of the planets as seen from the sun, which are called *heliocentric* places. But our own circumstances, as being ourselves revolving about the sun, cause the apparent planetary motions to vary most materially from the real ones, and the *geocentric* places (or places as seen from the earth) to differ literally *toto cœlo* from the heliocentric places. Thus, as seen from the sun, a planet moves from west to east, always: as seen from the earth, it sometimes moves from east to west. As to this point, the circumstances of our day are, in regard to the astronomical education of the world at large, a complete reversal of those which preceded the time of Newton. Formerly, the apparent motions were well known to those who knew anything; the real motions were matter of dispute: now, every well educated boy of fourteen has a very good notion of the real motions, while few, except astronomers, could distinctly explain the apparent ones, and maps of them are quite out of date. To explain these motions here would require us to introduce the contents of another article; the whole of what is necessary on this point will be found in Trochoidal Curves, the preliminary considerations being found under Motion.

The places of the principal planets are usually given in the almanacs, at intervals of several days, in a manner which is sufficient to find them in the heavens. In the 'Nautical Almanac' is to be found a Greenwich meridian ephemeris of every planet for every day in the year, in which the places are predicted to the smallest quantities, so that the reduced observation of any one day affords an immediate comparison of the theoretical tables with the fact.

PLANETARIUM. [Orrery.]

PLANING MACHINERY. Of late years the increase in the price of hand labour, and the necessity for securing mathematical accuracy in the surfaces of contact of the parts of machinery, have led to the application of other machinery to the preparation of the surfaces of wood, of stone, and of iron-work. The nature of the various materials has led to modifications of the tools employed, as might naturally have been expected; and it is worthy of remark that the application of machinery to this purpose has been much more successful with the more apparently intractable and hard materials, stone and iron, than it has been with the softer one, wood. Generally speaking, the tools used for planing wood, or iron, are fixed at a certain height, but are able to reverse the direction of their points; and the surfaces to be operated upon may be moved horizontally under the tools, so as to be attacked in their alternate motion, or only in one direction when the cutting tools are not susceptible of being reversed. In wood planing machinery the majority of the tools hitherto used in England have a rotary motion; and from this fact, and from the tendency of the wood to tear up, as the workmen say, it is necessary to finish the best class of joiner's work by hand labour. It may be also stated that until the introduction of planing machinery for iron, it was almost impossible to obtain a large and perfectly level surface on a plate of that metal; so that in fact this machine has been one of the most important agents in the advance of the arts connected in any way with the use of iron. The success of the application of machinery to the dressing of stone, or of wood, depends, however, solely upon the value of hand labour; and its introduction becomes a mere question of local economy, whence its more general use in America.

In the iron planing machinery there is a large bed or plate connected with the driving machinery in such a manner as to allow the bed to move alternately to and fro in a horizontal direction; and the tool or chisel is fixed in a carrier, so as either to reverse the position of its point when the bed has reached the end of its course, or it is raised on a horizontal pin so as to allow of its being lifted by the projections of the surface operated upon, and thus only to work whilst the bed is travelling in one direction. The distance between the bed and the carrier is regulated by a screw; and the width of the face of the tool is varied according to the greater or lesser quantity of iron to be removed, the finishing tool being wider than the roughing point. A slight burr is left on each side of the path of the tool, which is removed subsequently if a perfectly smooth face should be required. Almost all the tool makers of the present day manufacture these beautiful machines; but those made by Mr. Whitworth are certainly amongst the best, even if they be not the very best, of their class.

Mr. Hunter took out, some years since, a patent for a modification of the iron planing machinery, which has been applied with such remarkable success by the late Mr. L. F. Carnegie, in his flag stone quarries near Arbroath, that it must remain a matter of surprise that the use of the machine has not been more generally diffused. In Mr. Hunter's stone planing machine the bed moves under a chisel, of a width of face varying inversely with the amount to be removed, as in the case of iron planing engines, and the slight burrs are worked down by hand. The American stone planing machines seem to consist for the most part of rotary cutters of chilled cast iron which wear away by friction the surfaces exposed to their action.

The ordinary descriptions of wood planing machines consist of cutters, or steel plates, working with a rotary motion; but, as was before stated, they do not leave the finished surface in the state required for good work. The best American machines of this kind, however, have cutters like an ordinary plane iron, screwed to a carrier able to be adjusted over the board to be operated upon by means of a screw. In front of each cutter is placed a loose bar as near to the knife as possible, for the purpose of keeping the grain of the wood perfectly close immediately before the knife. For the best description of joiner's work the wood thus planed requires to be finished off with the smoothing plane, as in the case of the wood prepared by the ordinary jack, or trying planes used in ordinary hand labour. In the latter case the rough work is done by the jack plane; it is carried to a higher point by the use of the trying plane, and is finished by the smoothing plane.

PLANISPHERE. This term originally stood for any representation of all or part of the sphere on a plane; it is now out of use, at least in that sense. It has partially however been retained (and it would be desirable that this meaning should become fixed and general) to signify any contrivance in which plane surfaces moving on one another fulfil any of the uses of a celestial globe.

The instrument which we proceed to describe is one which when made correctly, at or near a given latitude, is, for ordinary uses, that is, for finding the position of the heavens at any one moment, much more easily used than the celestial globe, and very much less expensive. A circular disc of pasteboard, on which the stars visible in our latitude are laid down, turns on a second disc, round which are the days of the year on one circle, and the hours of the day on another. A third and hollow disc turns upon the same pivot, the hollow part being so cut that the portion of the heavens which it shows is precisely that which is visible at one time in the latitude of the instrument: the points of the compass are marked round the rim of the hollow disc, or of the horizon. The effect is, that by setting the disc which contains the stars to the day of the year, and the hollow disc to the hour of the day, the part of the heavens visible at that day and hour is distinctly shown. The time at which any star rises, culminates, and sets can be immediately found within a minute.

PLANTING and PLANTATIONS. Planting is the operation of placing in the soil the roots of a plant which has been previously removed; and the preservation of the roots is the first thing to be attended to. It should be kept in mind that the *spongioles*, or delicate extremities of the fibres, are the parts by which the chief supply of food from the earth is absorbed by the plant. Their tissue being tender and almost naked, they are very susceptible of injuries from mechanical action; and being adapted for performing their functions in a humid medium, they readily suffer from being kept for any length of time exposed to free air and drought. In taking up the plants, therefore, the roots should be loosened in such a manner as to receive the least possible violence in the operation. Plants in pots can be shifted from one place to another without exhibiting symptoms of deranged functions; and if it were possible to preserve the spongioles of a large tree as entire as those of a plant in a pot, the same successful result would follow. But as it is next to impossible to do this, we can only attempt to preserve them as far as circumstances will permit. If the tree be large, a trench should be opened beyond the extremities of the roots, of sufficient width and depth to allow the process of undermining to be freely carried on. The roots should be gradually set at liberty by a round-pronged fork, the prongs tapering so as to be easily inserted, yet not by any means so sharp as to prick the roots. As the fork is being used, the soil from among the roots will fall into the open trench; but as it accumulates there it must be cleared away, and at the same time the portion of roots set at liberty will require to be slightly tied together with pieces of matting, and, if necessary, supported by temporary stakes, or held to one side by an assistant, whilst the planter proceeds in liberating others. If there be, as is frequently the case, a tap-root extending to a much greater depth than the other roots, and if the latter have been carefully preserved during the operation, the tap-root may be dispensed with, for it could only be raised in a mutilated state, owing to the great solidity of the earth at such a depth.

Although it is very desirable to preserve the greatest possible quantity of sound roots, yet all that are bruised or lacerated should be cleanly amputated up to the sound parts. Cross-roots are apt to gall the others when they become large, and therefore the sooner they are removed the better. When the plants are young, and in the course of being occasionally removed in a nursing state, all irregularities in the roots should be corrected, which can then be done with comparatively little injury, as the roots of young plants bear a greater proportion to the top than seems to be the case at a more advanced period of growth, and the loss of any of them is consequently felt less. In the early stage of rearing trees, while the proportion of roots predominates, it may be found advisable in various cases to shorten not only the tap-root, as above mentioned, but also judiciously some of the other strong roots, in order that subdivisions of a more fibrous nature may be produced, and a number of rootlets substituted for large root-branches. Even in the case of large trees this principle has been acted upon for centuries, and latterly it has been strongly advocated and put in practice for the purpose of producing immediate effect in park or landscape scenery. A trench is cut out round the tree, and the roots shortened wherever they happen to traverse this trench, so as to leave it quite clear. This being done, the trench is filled up, either with its own excavated soil, or, in very particular cases, with fresh soil. The tree has still a sufficient number of undisturbed roots to keep it alive; and in fact it ought not to be merely kept alive, but as many roots should be left as will ensure its continuing in a healthy though not a vigorous state of growth. In the course of a year or two after this operation has been performed, a number of young roots will have been protruded from the various amputations into the loosened soil of the trench; and partly from the possibility of preserving these roots, and partly from the top becoming habituated to a more limited supply of food, the tree feels comparatively little the change consequent on transplantation.

Roots may be produced of a proper description for planting by the adoption of such means as the above, and if care be taken they will suffer little from the operation of removal. Still they may be seriously injured from exposure to air, and more especially to drying winds, frost, and even to wet. To be covered in the soil is the natural condition of the roots of most vegetable productions, and therefore endeavours should be made to place them in such a condition with the least possible delay; or at all events, if circumstances render delay unavoidable, such means should be adopted as will preserve them in a state of moisture similar to that which they have in the soil. It is however necessary to observe, that when the tops are closely packed up and evaporation from them prevented, the roots should be kept rather dry than otherwise; for under such circumstances, damp is found to be much more frequently destructive than a little dryness.

Though the preparatory steps to planting, as regards roots and their preservation, may be properly taken, yet, if the operation be not performed at the proper season, success will not be complete. It is true that instances may be adduced of planting being done at the very opposite season to that which is here recommended as the best; but such cases are only examples of what may be done by extraordinary care in adopting artificial means so as to imitate more natural circumstances. It is a well-known fact that plants are subject to a process of evaporation from all the parts which are exposed to the atmosphere, provided the latter is not in a state of saturation. The source from whence this evaporation is supplied is the moisture of the soil, and the roots are the media by which it is collected and transmitted to the stem, branches, and leaves. If the expenditure be greater than the supply of moisture, the plant will begin to suffer; if the disparity be great and continued, a degree of desiccation will be occasioned sufficient to deprive the vegetable tissue of that moisture which constitutes the medium of intercommunication between the different cells; organisation is destroyed; the chain which connected it with vitality is broken, and incapable of being re-united by any mechanical means.

A much greater amount of evaporation takes place from a given surface in some species than in others; but the amount as regards plants of the same species, all other circumstances being the same, is in proportion to the extent of surface which the respective individuals possess. The leaves of a lime-tree may have a surface equal to thirty times that of the stem, branches, and twigs which produce them, and consequently the demand on the roots for the supply of evaporation will be thirty times greater when in leaf than when the branches are naked. Instances might be adduced in which this difference would even be exceeded; but if, on the contrary, it were found considerably less, still there would be sufficient evidence of the impropriety of moving plants when in leaf; and it may be here remarked, that young leaves admit of the fluids being more rapidly evaporated than old ones.

The month of December is that in which the condition of the air with regard to moisture approaches nearest to that of complete saturation, and next in this respect is January, which is also the coldest. It might therefore be concluded that these months are the best for planting, more especially as they are the most opposite in character to June and July, which, from their being the hottest and driest, are found to be the worst. But November is also moist; and although the temperature of the season has not then reached its minimum, yet the foliage, accustomed to exercise its functions under a summer heat, can no longer perform them under a reduction of temperature, which, though not the lowest, is comparatively low as regards summer productions. The leaves in consequence lose their connection with the roots; the earth still retains considerable warmth; and although the absence of leaves in deciduous trees, and perhaps the inactivity of those of evergreens, may prevent the formation of wood, except in the most limited degree, yet the buds, whilst they are themselves increased in volume, maintain a corresponding action in the roots, sufficient in many instances to form fresh spongioles before winter, a process which is favoured by the soil being warmer than the atmosphere. Should circumstances occur to prevent the actual protrusion of cellular substance in the form of spongioles, still an accumulation of it will be taking place, ready to burst forth in spring. On this account therefore, although December, January, and February are sufficiently moist, yet November, or as soon as the leaves have fallen, is the preferable season for planting. There may be some exceptions, as in the case of very wet soils, where the plants, if not firmly rooted, are liable to be thrown out during winter, owing to which spring planting would be more proper. But under ordinary circumstances all deciduous trees will succeed best at the period above indicated. Such species as push forth their buds early ought certainly to be planted in autumn. Many of the coniferous tribe will succeed well if planted soon after they have made their summer's growth: the earth is then warm, and the plants make roots very promptly. Some species of this interesting order of trees require to be planted either before winter, so as to have sufficient time to strike root, or immediately before their buds begin to burst in the spring. These species of trees are injuriously affected by exposure to dry cold winds, even when their roots are undisturbed by removal; but if planted at a season when several months must elapse before any perfect action can commence, the tops are apt to become dried up in the interval. It appears that if their juices become inspissated to a certain extent, they never again become liquified, probably owing to their resinous nature.

The watering of newly planted trees ought to be attended to. The supply in the first instance should be copious, in order to wash the earth into the cavities among the roots. Some err in keeping the roots of newly planted trees constantly soaked with water, as if they were those of bog-plants, for which only such treatment is proper. In watering, consideration should always be had to the nature of the plant, to which, if it delight in dry soils, no more water should be artificially applied than is necessary to moisten it as much as the soil in which the species grows naturally, and at a time when shoots and leaves are abundantly produced. When watering is performed, it should be done thoroughly, so as to reach the lowest portions of the root. In the case of plants being much dried from long carriage or other causes, the supply on first planting should be very moderate. The tops however should be frequently syringed, in order to moisten the bark and prevent its absorbing the organisable matter which descends towards the root by the inner bark. The flow must be extremely weak under such circumstances; but if it can be preserved from the effects of drought till it reach the extremities of the roots, the formation of fresh spongioles will immediately commence, and the tree may then be pronounced out of danger.

The manner of performing the operation of planting may be reduced to one general principle, that of placing the roots in the soil so as to imitate as closely as possible the position which they occupy when growing wild and uncontrolled. Plants indeed may be instanced whose roots have been observed in one situation penetrating to the depth of four or five feet; or in another, creeping along the surface, amongst stones, or into the crevices of rocks, with scarcely soil to cover them, as for example in the vine. But although roots can usually accommodate themselves to that position which the nature of the situation renders it alone possible for them to occupy, yet there can be no doubt that in all cases the extremities of the roots should be lower than where they diverge from the stem, a rule which, however self-evident it may be, is frequently violated in practice by making a basin-shaped hole, deepest in the middle, in which the roots are either doubled or have their extremities tending upwards on the sloping sides of the cavity.

The excavation for the reception of the roots of a plant should be considerably larger than those roots will traverse when extended at the time of planting. It should be as wide at bottom as at top. The bottom should be more or less convex, and the depth such as to admit of the roots being covered to the extent observed in undisturbed seedling plants of the same species; that is to say, the upper part of the root should only be just covered. The lower roots should be regularly disposed over the convex bottom of the excavation, and carefully strewed with some of the finer portion of soil, over which the other roots may be spread. More soil should then be carefully rather than forcibly introduced. There should be no vacant spaces left, except those of so minute a description that they will be readily filled up by the finer particles of earth washed down by a plentiful watering. This watering should be given when the soil is nearly all filled in; and after the water has subsided so as not to stand above the surface, the latter should be covered with the remaining portion of soil. Except in very loose or light soils, this method will supersede the necessity of the hard beating and treading in to which the roots of trees are very generally subjected. The latter practice is now however being laid aside by many, from a conviction of its injurious effects. It is also necessary to remark that a plant should be placed, before the introduction of the soil, exactly as it is intended it should stand; and it should not be pulled from side to side for the purpose of shaking the earth amongst the roots. If the tree be drawn to one side, the fibres of the root will also be drawn towards the same side; but they are of course too flexible to force their way back when the tree is drawn in a contrary direction, and they must therefore become more or less doubled. Nor should the soil be thrown *against* the fibres whilst the roots are being covered; it should be made fine, and either shaken from the spade so as to fall perpendicularly among the roots, or scattered by a force impelling it in the direction of the fibres, which will be in general from the stem towards the extremities, or from the centre to the circumference.

The principles here stated are applicable to the planting of large as well as small trees, and in fact to any terrestrial species of plant. There are, however, many modifications in practice, some of which may be noticed as proper under certain circumstances, and others as only to be condemned under any circumstances whatever.

Small plants are very frequently inserted by the *dibber*, a cylindrical piece of wood, shod with iron and tapering to a point. This is thrust into the soil, and in the hole formed by this means the roots of the plant are introduced, and a portion of soil pressed towards them by a second stroke of the dibber. It is evident, however, that by this procedure the roots cannot be in the most natural position; they are in fact the very reverse of being spread out to the best advantage. In the case of very valuable species the spade or planting-trowel is used in preference to the dibber. The latter has nothing to recommend it on the score of good principles in planting; the expedition with which it can be employed is all that can be said in its favour.

Besides the spade and dibber, various other implements are used in planting, such as the *diamond dibber*, a pointed plate of steel with a short iron handle; a *mattock*, used in stony soils; and some others, adopted according to circumstances. In all cases, however, where the spade can be used, it is undoubtedly the best instrument. If the soil be unfit for allowing the use of the spade, it should be rendered fit previously; and if some time be lost and expense incurred by using it instead of smaller and more expeditious, but at the same time more cramping implements as regards the roots, the difference will certainly be ultimately in favour of a proper disposition of the roots by means of the spade.

With regard to the preparation of the soil for plantations, it is found that trenching the ground is attended with profit where it is practised for the purpose of rearing wood for fuel and small timber. This mode of preparation ought likewise to be adopted where trees are intended to be planted for ornament or for shelter. It has not been generally attempted in the case of extensive plantations of heath or rugged mountain-land. It may, however, be affirmed without hesitation that great advantages would be derived from the operation being more extensively performed. Something more than merely burying the roots of hard-wooded plants is thought necessary, and accordingly *pits* are made. It is scarcely necessary to observe that if these are not of considerable size, the direct progress of the roots is soon obstructed. The time required to form these pits as they ought to be, would be sufficient to regularly trench double their area. The expense of trenching the intermediate spaces will be compensated by the greater return derived from the nurse plants, such as larch, when they come to be removed.

Plantations are generally planted thick in the first instance, and with various species of trees. Larch, Scotch fir or pine, mountain ash, &c., are interspersed amongst the hard wood for shelter, or as nurses. Laburnum is also useful for preserving the other sorts from the depredations of hares, as they prefer the laburnum to every other bark. Nurses are generally left till they are fit for various purposes for which small timber is applicable. They should be planted closer to each other than to the principal trees intended to constitute the more permanent part of the plantation.

After all the care of the planter and the skill with which the operation of removal may have been effected, much of the success of a plantation depends on the proper adaptation of species to the soils and situations most suitable to them.

The following remarks upon some of the timber-trees principally cultivated may be useful.

The oak, *Quercus robur*, and *Q. sessiliflora*, prefers strong or even clayey loam; any soil not wet or chalky.

Beech, *Fagus sylvatica*, calcareous soils, gravelly or sandy loam; dislikes stiff clay.

Elm, *Ulmus campestris*, *U. glabra*, *U. montana*, attains, near the banks of rivers, a large size; thrives in most soils.

Ash, *Fraxinus excelsior*, prefers a dry subsoil; dislikes stiff clay.

Plane, *Platanus orientalis*, rich warm soil, tolerably moist, but not retentive.

Sycamore, *Acer pseudo-Platanus*, *A. platanoides*, best in moist deep soil, but will thrive in others not too stiff; withstands the sea-breeze.

Chestnut, *Castanea vesca*, deep sandy loam.

Walnut, *Juglans regia*, deep loam with a pervious subsoil; dislikes strong clays.

Hickory, *Carya alba*, similar soil to that required by the walnut.

Acacia, or locust-tree, *Robinia pseud-Acacia*, sandy loam; a sheltered situation; cannot bear storms.

Birch, *Betula alba*, forms best timber on dry sandy or gravelly soil.

Laburnum, *Cytisus alpinus*, any soil not too wet.

White Bean, *Pyrus Aria*, any good soil, with a pervious subsoil dislikes wet clay.

Lime, *Tilia Europæa*, soft deep loam, in low rather moist situations.

Horse-Chestnut, *Æsculus Hippocastanum*, deep loam; not in exposed situations.

Poplar, *Populus alba*, *P. canescens*, *P. nigra*, *P. tremula*, *P. fastigiata*, *P. Græca*, *P. monilifera*. These thrive in almost any soil, but best in that which is deep and rather moist.

Mountain-Ash, *Pyrus Aucuparia*, any soil, wet clay excepted; adapted for high situations.

Alder, *Alnus glutinosa*, moist or even swampy soil.

Willow, *Salix*, of numerous species. Some thrive in rather dry soil, but all prefer moist.

Pine, *Pinus sylvestris*, *P. Laricio*, *P. Pinaster*, *P. Strobus*. The two first are adapted for thin, rocky, gravelly soils; they grow at a great elevation on the warmest sides of mountains, but better in mountain glens; they dislike stiff clay and deep strong loam, and, like all coniferous plants, they do not thrive on chalk. *P. Pinaster* and *P. Strobus* require a less exposed situation than the other two.

Spruce, *Abies excelsa*, *A. alba*, *A. rubra*, *A. nigra*, deep moist soil, in low situations; dislikes thin sandy soil and exposure.

Larch, *Abies Larix*, adapted for thin mountain land, or any soil of which the subsoil is not retentive, excepting, however, red sandstone or chalk, as above mentioned.

Cedar of Lebanon, *Abies Cedrus*, any tolerably good soil, rather deeper than for the larch, but a pervious subsoil, free from stagnant water.

Too close planting produces weak drawn-up timber, in consequence of the tops only receiving a due share of light. It is true that the most magnificent trees are found in those ancient forests that have never been sown, planted, or thinned by the hand of man. But at the same time it will not be denied, that wherever natural forests exist, the soil and situation must be exceedingly favourable for the species produced; and that although thousands sprung up more than could possibly find room to attain perfection, yet those only that were the most favourably circumstanced and most vigorous would continue; and when once their tops got completely above those of the general mass, the latter must have inevitably fallen into decay. There is no reason, however, to suppose that those which maintained their ground, and, favoured by propitious soil, became lofty specimens, would not have been benefited by the assistance of the axe to relieve them sooner from their rivals.

If, on the contrary, trees are planted at too great a distance from each other, they are inclined to ramify into large limbs and spreading tops, with a stem short but much thicker than where the space admits of less expansion of foliage. If therefore very thick timber of no great length be required, wide planting is proper; but if tall timber be the object, the plantation must be moderately thick.

The care which plantations require from year to year consists in making up deficiencies, thinning and pruning. Deficiencies seldom occur if the planting be at first duly performed; and every endeavour should be used to prevent the necessity of *making up*. This is always done with considerable disadvantage to the plants thus introduced, unless the spaces be trenched; but in that case, if the species of tree be properly chosen, the plants may do well in consequence of the shelter afforded by the older surrounding individuals.

Thinning should be commenced in due time. No branch of the temporary trees should by any means overhang the top or even branches of those that are permanent. The shelter on the most exposed sides of the plantation should be formed of robust, vigorous, growing kinds, and it should be allowed to remain unbroken. Plantations that have been neglected till they have formed a dense thicket must be thinned gradually; for if thinned at once, those left would be injured by the sudden exposure, and would be blown over by winds.

Pruning is an important operation in the management of plantations, but it is often improperly practised for want of the knowledge of a few physiological facts, which are essentially necessary to be stated before any rules for pruning can be properly given. If these facts be understood few rules will be required, but otherwise a volume of directions are liable to be misapplied. It ought therefore to be understood, that the sap ascends from the stem chiefly through the alburnum, or outer layers of young wood. It then enters the leaves, when it is exposed to the influence of light. Having in consequence undergone an elaboration, it descends on the outside of the alburnum, that is to say, through the inner bark, the internal surface of the latter possessing a great degree of lubricity, whereby the passage of a portion of the juices at least is facilitated to the roots, whilst part is detained and becomes organised by the action of the medullary rays, forming a new layer of woody matter. The thickness of the layer so formed is very different in different species; but in the same species, all other circumstances being the same, it is in proportion to the surface of leaves. The aggregate horizontal growth, or in other words the diametrical extension of the stem, branch, and even roots, depends upon the quantity of healthy foliage. The diametrical increase of any particular part corresponds with the greater or less proportion of foliage above that part. Again, it may be stated that if any one tree has a clear stem of 20 feet in length, and another has one of 40 feet, the roots and foliage of both being equal, the layer of new wood will be much thinner in the latter case than in the former; for the deposition of woody matter will have to extend over double the surface in the tall tree. It may be also remarked, that, in general, if a tree be left entirely to nature, it will ultimately produce a greater bulk of wood, taking stems and branches together, than would be the case if subjected to pruning. Except however in the case of growing for fuel, pruning is more or less necessary. The value of a timber-tree depends chiefly on the stem, the branch timber being of less value. The object to be kept in view in pruning for timber is the production of a clean stem with as small a proportion of branches as possible. But it has been explained that the growth of the stem depends on the quantity of foliage, and without branches a sufficient quantity of foliage cannot be maintained. Whilst, on the one hand, an undue preponderance of branches is prevented by pruning, yet, on the other, as much foliage should be preserved as circumstances will permit.

An excessive privation of foliage should never be occasioned at any one time. It is therefore advisable that pruning should be commenced early, in order, as it were, to repress irregularities in the bud. At all events, whenever an irregularity can be clearly distinguished as such, it should be checked. Thus, when a shoot, occupying the position of a branch, ascends in competition with the top, or leading shoot, and is allowed to go on for years, the stem will have a forked character; or if the competing portion be amputated after it has acquired a large size, the timber will be rendered unsound. But if the shoot from which this aspiring limb took its rise had been stopped in the first or second season of its growth in summer, the tree might have been grown with a clean regularly tapering stem. It is only great irregularities however that should be meddled with during the early growth of the plant; otherwise the increase of roots is prevented, such increase being reciprocal with that of the branches.

Young shoots of the above description may be checked by being shortened in summer; but no large branches should be cut off at that season, nor after the sap begins to flow briskly in spring. Towards autumn, however, when the leaves have nearly ceased to carry on their functions, pruning may be very properly performed; and some species, for example the birch and maple, require to be pruned at that time, otherwise they are apt to bleed. The period at which *bleeding*, that is, an extravasation of sap, takes place with greatest force, is immediately before the bursting of the buds in spring. If a branch be cut off when in foliage, the remaining portion draws the sap and prevents effusion at the wound. Some derangement will of course be produced in the flow of sap; and a diminution of the process of lignification and of the formation of roots will be occasioned, owing to the abstraction of a certain extent of foliage. But when the sap is in motion, and the leaves at the same time not expanded, the amputation of a branch is followed by a flow of sap, which appears to drain from every part of the tree. The sap becomes stale on exposure to the air; it then affects the cambium and inner bark, often to a considerable extent below the wound, and if these are not in all cases so far completely killed, yet they are generally more or less injured, and canker is apt to ensue.

Supposing it were required to rear a tree so as to have a stem of clean-grown timber, as tall and as thick as could possibly be obtained in any given time. The first consideration is the root, the plant being supposed to be young, with a top or upright leading shoot, and several side branches. All these should be left undisturbed in the first instance, unless such of the latter as may require a check if growing too strong for the others or for the leader. The laterals should be left, for the sake of the roots, till their presence on the stem becomes inconsistent with the object of producing it as free as possible from knots, taking also into consideration that the difficulty in healing the wound increases as the branches get older. A *few* of the largest shoots should be those first removed. They may be shortened in the first instance after midsummer, and afterwards cut off smoothly by the lowest circular wrinkles which form round their base, close to the stem, but without slicing off a portion of the bark; a slovenly practice, of which only bad pruners are guilty, and which can only have the effect of diminishing the power of the bark to close over the wound necessarily made by the pruning-knife. Such unnecessary wounds cause an extravasation of sap, as may be seen especially in coniferous trees, where they are generally covered with resinous exudations. In the following season the next largest branches should be in like manner displaced, care being still taken, on account of the importance of the foliage, as already explained, that the quantity removed shall be no more than is absolutely necessary.

Small branches along the stem should be left till they approach the dimensions by which the removal of the others is regulated. These principles should be followed up till the required height of stem is attained; after which the branches composing the top shall be allowed full freedom, in order to increase, by their organising power, the diameter of the stem.

Coniferous trees require little pruning; nor is it necessary to commence so early with them as in the case of other kinds. In dense forests they are found with straight stems approaching the height of 100 feet clear of side branches, the latter gradually decaying below as they become excluded from light and moisture by those above them. When from this cause the lower branches of coniferous trees are observed to lose in a great measure their vigour, and when their foliage contributes little to the enlargement of the stem, they may then be very properly cut off, without waiting for their actual decay. It is a question whether the branches of these trees should be cut close to the stem at once, in pruning; or whether they should first be *snagged*, that is, cut at some distance from the stem, and either allowed so to remain or be afterwards cut close. That plan is best to adopt by which the least exudation of resinous substance is occasioned, and the blemish soonest overgrown. With the view of preventing the former, the branch may be shortened only to the first live twigs, so as almost to nullify its connection with the stem, preparatory to its final and close removal in the following season.

By choosing the proper season, and by previous shortening, large limbs of any healthy tree may be closely amputated so as to heal over without affecting the tree generally, or even the portion of stem more immediately connected with the limb to any material extent; yet the new layer of wood will prove, on cutting up the timber, to be only in close contact with the surface of the wound, which will remain dead, and with which the living matter enclosing it could not coalesce. A piece of unsound wood is thus embodied. In this case it would be advisable to shorten the limb to such of its laterals as will just be sufficient to keep it alive till the tree is felled. If, in the interval, the branch should push vigorously, means must be adopted to keep it always in a reduced state, by merely allowing as much foliage as will keep the branch alive, without affording any material addition to its diameter.

The proper season for felling trees is when the sap is most at rest. The operation ought not to be performed at any other time, unless for fire-wood. The quantity of sap that may be drawn from some trees is very great. This sap contains the elements of fermentation, the powerful effects of which are evident even on the strong fibre of the oak. Softer woods, although very tough if cut at the proper season, have been observed to crumble almost to powder in a year or two, in consequence of having been cut when in sap.

(Sang's *Planter's Kalendar*; Loudon's *Arboretum Britannicum*; *Encyclopædia of Gardening*; Morton's *Cyclopædia of Agriculture*; Stephens' *Book of the Farm*.)

PLASTER OF PARIS. [CALCIUM; *Sulphuric Acid and Lime.*]

PLASTERING. The application of any coat of plastic material to the uneven surfaces of masonry or of wood-work, for the purpose of bringing the latter to a sufficiently smooth surface to receive elaborate surface decoration, is known by the generic name of plastering: but in practice a distinction is made in order to separate the more elaborate processes of the plasterer's art, which are known by the names of stuccos, scagliolas, &c.

Ordinary plastering is either executed with the pure dehydrised sulphate of lime (or the baked gypsum), or with mortars composed of the carbonates of lime, forming a substratum to receive ultimately a finishing coat of fine plaster; the choice between those materials being decided by motives of economy, for the gypsum does not occur in large quantities, or over large areas, although it is found in a great many countries. When the carbonates of lime are used for plastering, great precautions must be taken to ensure their perfect hydration before they are put upon the walls, as any unslaked lime will be sure to attract moisture from the atmosphere, and to slake, or, as the workmen say, "to blow." Near London the usual practice is to cover the walls with a rough coat of lime so slaked, mixed with sand and with cows' hair, for the purpose of counteracting the tendency of the lime and sand mortar to contract unequally, and thus to crack, in setting. This coat is called the *rendering coat*, and in good work it is left with a roughly trowelled face, able to *form a key* for the further finishing coats; but in commoner descriptions of work, known as *laid work*, the rendering coat is at once *floated*, or worked to such a surface as to be fit to receive the finishing coat. In good work upon walls, the rendering coat is then covered with a second coat, called the *floating* one, with which great pains are taken to secure its verticality and its evenness; and upon this again the *setting coat* of pure lime is applied, which is trowelled up with more or less care according as the surface is intended to receive paper or paint. Upon ceilings, or wooden partitions, the several rendering, floating, and setting coats are applied, in the same order as above, upon laths; and the laths themselves are either prepared from oak or from fir. In ceilings, however, it is customary to add, after the setting coat, a very fine one, composed of the sulphate of lime, or of what is commonly called the "plaster of Paris," whether obtained from our own or from foreign quarries.

The manner in which plastering is executed in Paris itself may be considered to present the best type of the application of the sulphate of lime for that purpose. The gypsum there used is obtained from the quarries of Belleville, Montmartre, Triel, or Vaux, and it is usually dehydrised in kilns heated by wood; the stone is said to contain a certain proportion of the carbonate of lime, and it certainly is harder than the English gypsum, on which latter account it may be that the French plastering is so much harder than the plastering executed with the Derbyshire gypsum. Workmen, indeed, consider it an axiom, that "the harder the stone, the harder the plaster." After the gypsum has been burnt, it is ground or pounded, and applied to the walls as soon as possible after that operation; the coarser kinds are used to render the uneven surfaces tolerably level, and the finishing coats are executed with the finer materials. The rough rendering is often laid on with a broom, and the setting coat is applied upon it by the application of rather stiff plaster floated under a rule, but finished immediately with the trowel; in fact, ordinary French plastering is no better than English laid work, and it is quite as uneven and as irregular as the latter. In the execution of their ceilings, the French plasterers adopt a different system from the one used in England; for they generally nail their laths at wide intervals, and upon them they lay slabs of old or rough plaster, which they bind together by new materials, so as to produce, as it were, a single solid slab of light plaster over the whole ceiling, which is subsequently made smooth on the under side by the addition of a setting coat. This description of ceiling is heavier than the English ones; but it resists the transmission of fire more successfully, and it is also less permeable by sound: the latter inconvenience of English ceilings is sometimes obviated by the introduction of sound boarding, or of pugging—which, however, are objectionable on the score of their tendency to develope the dry-rot in the joists of the floors.

There is one remarkable difference in the action of the lime plastering and of the gypsum plastering, arising from the fact that the crystallisation of the latter is accompanied by an expansion so energetic, that if it be not provided for very serious accidents would occur; whereas the lime plastering, as a general rule, has a tendency to contract. Of whatever materials the body of the plastering may be formed, the finer mouldings, and all the cast ornaments, are executed in fine plaster, unless the cements, or the prepared sulphates of lime, known as the Parian, Keene's, or Martin's cements, are used. The class of materials last named are obtained by the calcination of a previously dehydrised sulphate of lime, soaked in solutions of alum, borax, &c.; and they produce remarkably hard and smooth surfaces, admirably adapted to receive paint; unfortunately, their use is costly.

Stuccos are made by the application, as a setting coat, of lime mixed with calcareous powder, plaster, and other ingredients, which is trowelled up by dint of excessive labour to a fine surface resembling marble, and able, like marble, to receive a polish. Different colours are given by mixing with the lime the metallic oxides of the required tints; and the polishing is effected only when the whole of the moisture has worked out of the lime. The mode of polishing is by the use of fine grits, tripoli powder, and oil rubbers, in nearly the same manner as for marble. Scagliola is in fact a species of stucco, but it is executed by the introduction of small particles of fine spars, or of coloured marble, into the rendering coat, in addition to the simple lime powder, so as to produce the effect of the more ornamental descriptions of marble breccias. Both these ornamental kinds of work are adapted for internal decoration, but externally they are exposed rapidly to decay. It may also be added that, in the construction of concert, or even of debating-rooms, it is preferable to finish the walls with ordinary plastering than with stucco, or scagliola, for the latter materials are so elastic that they reflect sound in a manner to interfere with the purity of the tone.

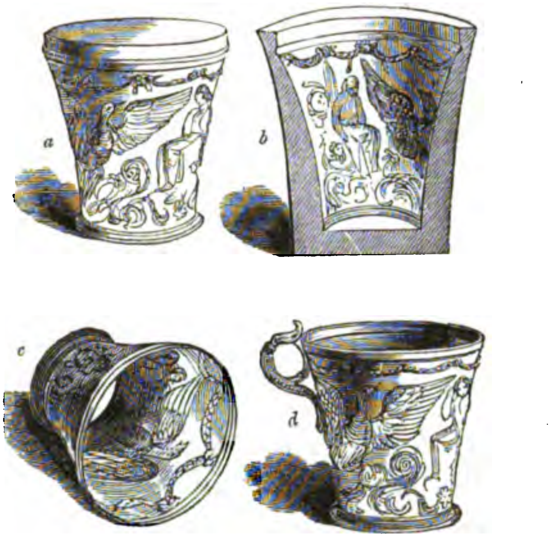
Whatever mode of plastering may be adopted, it is essential that the walls on which it is applied should be perfectly dry, and perfectly impermeable, if any elaborate surface decorations are to be applied to them. Great precautions must also be taken to secure the absence of organic matters in the materials used, for if any of them should be present, the nitrogen salts will be thrown out, under such circumstances as to destroy any painting or papering on the walls. It is precisely to the neglect of this precaution that we may attribute the loss of so many noble fresco paintings.

PLATE; PLATING. In the article JEWELLERY, JEWELLING, it is explained that under the general name of *plate* are included the productions in gold and silver which are stamped at Goldsmiths' Hall and similar places, while *jewellery* comprises the smaller articles which are not so stamped.

Confining our attention to plate, properly so called, it may be stated that all such articles made in and near London must be sent to Goldsmiths' Hall, after having been stamped with the maker's mark. Persons used to the work scrape off a few fragments for the purposes of assay; if this be found to be below the standard (in gold 18 carats fine), the article is broken up; if of proper standard, it is stamped and returned. Most of the plate is made in and near Clerkenwell, although the chief goldsmiths have their retail establishments at the West End or in the city; and there is at all times a busy system of transmission between Clerkenwell and Foster Lane, where the assay office of the Goldsmiths' Company is situated. The company receive fees for assaying and stamping, amounting in the aggregate to about 4000*l.* a-year, from the manufacturers. They also receive about 2000*l.* a-year from the government, for their trouble in collecting the Excise duty on gold and silver plate, and paying it into the Bank of England. This curious arrangement seems to have arisen from the circumstance that, as it is a part of the company's duty to ascertain exactly how much precious metal there is in each manufactured article, they have the means at once of stating how much duty is payable to the government, at a certain rate per ounce. This rate is 17*s.* for gold and 1*s.* 6*d.* for silver, if estimated at the full weight; but as there is always a slight reduction of weight during the finishing processes which follow the assaying and stamping, the government take off one-sixth of the duty, leaving it at about 14*s.* 2*d.* and 1*s.* 3*d.* respectively. There have in recent years been about 50,000 of these assayings made in a year. The assayers are not allowed to know from whose manufactured goods the particles have been scraped off; each packet is opened, assayed, and reported on with perfect fairness. If any manufacturer has erred frequently by sending in goods below the standard, the officer who receives the goods may direct any subsequent specimens from him to be tested with additional severity. Out of London, the towns in which the largest amount of gold and silver plate is manufactured are Birmingham and Sheffield; halls or assay offices are established there, with duties nearly like those of Goldsmiths' Hall; and at those places a curious operation is conducted, relating to *diets* of gold and silver. An assayer scrapes eight grains from every troy pound of plate manufactured, and divides it into two portions, one of which is at once assayed; the other is placed in a receptacle called the *diet-box*, which, at the end of the year, contains specimens from all the articles manufactured. This box is sent up once a year to London, where the assay master of the Royal Mint assays a fair average of all the small portions which it contains: if this average reaches the standard, the assayer at Birmingham or Sheffield receives a certificate; if below the standard, he is fined. There are a few other assay offices in the United Kingdom, each having control over the gold and silver plate made within a certain district. The Goldsmiths' Company have often petitioned for the abolition of these country offices, on the plea that the assays are more scrupulously made by the company's servants than by those of the local halls; but it is difficult to get rid of the influence of self-interest in connection with any such plea. It is admitted, however, that plate stamped with the London hall-mark commands a higher position in the market than that which has only a country stamp. In recent years there have been (in round numbers) about 10,000 ozs. of gold plate, and 1,000,000 ozs. of silver plate, assayed and subjected to government duty annually in the United Kingdom.

The manufacturing operations do not call for detailed notice here. The processes of rolling, casting, punching, chasing, hammering, stamping, soldering, riveting, and burnishing, all come into requisition in the manufacture of a piece of plate of any considerable size or elaboration of design.

The proportion, however, of articles of plate made of real gold or silver throughout is very small compared with that of articles in which the surface only is of precious metal, laid upon a metal of cheaper character. By pressure between steel rollers, a thin layer of gold or silver may be made to adhere to a thicker layer of some cheaper metal, and of the compound layer thus produced numerous articles may be made. A class of goods called *Sheffield plate* used to be very largely manufactured of such compounds. The product has been considerably improved by the adoption of a white metal for the ground or foundation. This white metal is usually a compound of nickel with certain other metals; and the colour bears a sufficiently close resemblance to that of silver to render it advantageous in all, since it will not show a coppery or brassy tint when the silver is worn away. Articles of real silver plate are sometimes coated with real gold on one side, or in certain parts, and these obtain the designation of *silver-gilt*. The whole trade, however, has undergone a revolution within the last few years, by the introduction of the process of *electro-metallurgy*, or *electro-plating*. By this process a work of art may be made wholly of gold or silver, or of a film of those metals on a ground of less value, by deposition from certain chemical liquids through the agency of a galvanic battery. The processes are explained under ELECTRO-METALLURGY. The annexed wood-cut will illustrate the remarkable series of operations (as described in that article) by which the better kinds of electro-plate are produced: *a* is a model for a silver cup, formed of wax or composition, and sculptured with an artistic design on the outer surface; *b* is one half of an elastic mould, made of caoutchouc and other substances, and obtained by casting from the model, with the device inside instead of out; *c* is a copper cup obtained by electro-deposition upon the interior of the mould, and afterwards detached from it; *d* is the finished cup, with an electro-silver surface upon an electro-copper ground, and a handle attached. If possible, white metal is used instead of copper as a basis.



There are many curious modes of coating plates of metal with thin films of other metal, wholly distinct from those in which gold and silver are employed. Most of them, however, bear analogy to TINNING or TIN-PLATING, and will be briefly adverted to in that article.

PLATFORM, Military, is the floor of wood or stone on which heavy guns are placed in order to be more easily worked. In fortresses the platforms are occasionally made of stone in order to withstand long exposure to the weather, but in field-works they are always of timber. For guns the platforms are laid with a slight rise to the rear (about ½ inch in the foot) to enable the gun to be more readily run up after the recoil. The mortar platforms are laid level. The ordinary gun and howitzer platform which, when laid, forms a rectangle 15 ft. long by 10 ft. 6 in. broad, consists of the following pieces:—

5	sleepers, each	15	feet long	× 5 in.	×	5 in.
20	planks ,,	10½	,,	9	,,	2 ,,
2	ribbands ,,	15	,,	4	,,	4 ,,
10	rack-sticks and lashings, or iron bolts.					

The weight of the platform is about 14 cwt.

The sleepers are first laid in the direction of the line of fire in cuts or trenches made in the ground, which has been previously levelled, and are firmly pinned down. They are then covered with the planks, which are laid at right angles to the line of fire, and, the ribbands being placed directly over the outside sleepers, are fixed down by the rack-lashings, which have been placed, five on each side, under the sleepers before they were laid.

The platforms may be fixed with screws, or spikes, instead of rack-lashings; but this, besides injuring the wood for further use, should it be necessary to move them, is a noisy operation, likely to attract the enemy's attention if the batteries are close to his works.

There is a description of gun-platform invented by Colonel Alderson, R.E., in which all the pieces, superstructure, and sleepers are of the same size, and are fitted together with dowel pins.

Platforms for mortars, which are laid horizontally, are generally 7 ft. 6 in. by 6 ft. 6 in. In order to resist the effect of the recoil of the mortar, which is fired at an angle of 45°, the sleepers and planks are stronger than in the gun-platform, and seven sleepers are used instead of five. Two sleepers being first laid transversely, then the five across them, and then the planking.

Madras platforms for guns are composed of a strong framework of wood, consisting of two side pieces, 12 ft. 6 in. long and 9 in. × 4 in., on which the wheels of the gun run, and two trail pieces 12 ft. 6 in. long and 4 in. square, for the trail of the gun (this platform being used for guns on travelling carriages). The whole platform is kept together and strengthened by a front and rear transom and three sleepers, to which the side and trail pieces are bolted down. The front transom is fixed close to the parapet, and the platform has a rise to the rear of 8 inches. This platform is very good for siege purposes, and when no great lateral splay is required; for when it is necessary to change the line of fire the whole platform has to be traversed with handspikes. Siege platforms, as has been stated, are generally made rectangular; but the stone platforms used in permanent works are made wider at the rear, so as to allow the guns a greater splay. This is not so much required in siege works when the guns have a fixed object, and would further make the platforms more complicated and difficult to lay at night, while the pieces not being uniform would not be interchangeable.

In fortresses, at the salients and in casements, and in coast batteries, the guns are now often mounted on traversing platforms. The gun is then raised on a platform which traverses on runners, the pivot being fixed either in front, centre, or rear.

PLATINAMINE. [PLATINUM.]

PLATINO-HYDROCYANIC ACID. [CYANOGEN; HYDROPLATINOCYANIC ACID.]

PLATINUM (Pt). The natural history of this metal has already been given. [PLATINUM, in NAT. HIST. DIV.] It has been very much used during the last fifty years in those experimental and manufacturing operations in which vessels are required that are not acted upon by hydrochloric, nitric, or sulphuric acids. Platinum knives, crucibles, capsules, and dishes, are commonly employed; while stills weighing from five hundred to one thousand ounces are not unfrequently made use of for concentrating oil of vitriol.

The metallurgy of platinum has of late years received considerable attention, and been greatly improved by MM. Deville and Debray. Their memoir appears in the 'Annales de Chimie et de Physique' for August, 1859, and is abstracted in the 'Pharmaceutical Journal' and 'Chemical News': its title is, "On Platinum and its Associated Metals." The following table exhibits at a glance the composition of platinum ores from various sources; for details concerning methods of analysis, see the paper above referred to.

	Columbia.	California.	Oregon.	Spain.	Australia.	Russia.
Platinum . .	80·00	79·85	51·45	45·70	59·80	77·50
Iridium . .	1·55	4·20	0·40	0·95	2·20	1·45
Rhodium . .	2·50	0·65	0·65	2·65	1·50	2·80
Palladium . .	1·00	1·95	0·15	0·85	1·50	0·85
Gold . . .	1·50	0·55	0·85	3·15	2·40	
Copper . .	0·65	0·75	2·15	1·05	1·10	2·15
Iron . . .	7·20	4·45	4·30	6·80	4·30	9·60
Osmide of iridium	1·40	4·95	37·30	2·85	25·00	2·35
Sand . . .	4·35	2·60	3·00	35·95	1·20	1·00
Osmium and loss		0·05		0·05	0·80	2·30
	101·15	100·00	100·25	100·00	100·00	100·00

The preparation of pure platinum from the ore is effected as follows. The ore is fused in a reverberatory furnace with an equal weight of galena, care being taken to avoid as far as possible any rapid oxidation of the lead. The mass is well mixed so as to convert all the iron into sulphide, and to produce an alloy of the platinum with lead; some glass is then added, and sufficient litharge to effect the decomposition of all the sulphides. The metal is then allowed to remain perfectly undisturbed for some time in order that the osmides may settle down and collect in the lower portion of the mass. The scoria is then removed; the alloy of platinum and lead run off, except the lowermost portion which contains osmium, and the lead finally removed by the ordinary process of cupellation. The fusion and refining of the resulting platinum are effected in furnaces made of solid lime and heated by a large jet of oxygen and hydrogen gases.

Nearly all the platinum at present met with in commerce contains traces of osmium and a little silicium, but these may be perfectly removed by prolonged fusion in the oxyhydrogen furnace just mentioned.

Pure platinum is a white metal of the same softness as copper, and is susceptible of high polish. It slowly volatilises at a temperature considerably above its melting point, and, on quickly cooling, bubbles and spirts like silver. In tenacity and ductility it is superior to all metals except iron. Its specific gravity is 21·15; or after hammering, 21·5. As a conductor of heat and electricity, it is inferior to gold and silver. It has the property of condensing gases on its surface, and when once heated to redness remains red hot for some time if a jet of cold hydrogen or coal gas be impinged upon it. Platinum is not tarnished by exposure to air, is unaffected by all acids except aqua regia, and is not acted upon by dry chlorine. It very readily combines with other metals, so that nothing that contains, or is likely to yield, a metal as such, should be heated in vessels of platinum. Alkalies also corrode it through formation of a double oxide.

Chlorides of Platinum.—Platinum dissolves in a mixture of three parts hydrochloric acid and one part nitric acid. Such a mixture (aqua regia) contains free chlorine, which unites with the platinum to form *bichloride of platinum* ($PtCl_2$). The latter may be obtained in deliquescent prismatic crystals on evaporation. It is very soluble in water, alcohol, or ether. On heating it to 450° Fahr., half the chlorine is expelled, and *protochloride of platinum* ($PtCl$) remains. Both chlorides form crystalline double salts with alkaline chlorides. The *potassio-chloride of platinum* ($KCl, PtCl_2$) is so sparingly soluble in water, that its formation is of considerable value as a qualitative test for potassium. Its insolubility in alcohol and ether admits of its being used as a means of quantitatively estimating potassium. The *ammonio-chloride of platinum* ($NH_4Cl, PtCl_2$) is isomorphous with the potassium salt, and is thrown down as a crystalline yellow precipitate on adding together tolerably strong solutions of bichloride of platinum and chloride of ammonium.

Oxides of Platinum.—The *protoxide* (PtO) is a black precipitate, formed on digesting the protochloride in caustic potash, and neutralising with sulphuric acid. It forms unstable salts with acids. The *binoxide* (PtO_2) is precipitated as a bulky brown hydrate, on adding carbonate of soda to excess of nitrate of platinum. It forms crystalline compounds with the alkalies and with acids.

Sulphides of platinum are formed by the action of sulphuretted hydrogen on proto- and bi-salts of platinum. The *protosulphide* (PtS) is gray, the *bisulphide* (PtS_2) black.

Iodides of platinum are produced by acting upon the chlorides with iodide of potassium. The *protoiodide* (PtI) is black; the *biniodide* (PtI_2) is deep wine-red.

Bibromide of platinum ($PtBr_2$) is a brown insoluble powder.

Nitrate of platinum ($PtO_2, 2NO_5$) remains in solution when nitrate of potash is added to bichloride of platinum so long as potassio-chloride of platinum is deposited.

Compound platinum and ammonia bases. Platosamine, platinamine, &c.—By the action of ammonia on protochloride and bichloride of platinum, and by the action of nitric acid, &c., on the resulting products, a series of remarkable compounds have been produced by Gros, Reiset, Gerhardt, and Raewsky. These bodies seem to be derivatives of hydrated oxide of ammonium, containing platinum in the place of hydrogen: they bear a striking resemblance to the ammonium ORGANIC BASES.

Spongy platinum is a dull-gray, soft, porous form of platinum, having somewhat the appearance of sponge. It is produced on simply igniting the ammonio-chloride of platinum. It possesses in a high degree that power of inducing the combustion of inflammable gases in the manner already alluded to. When freshly prepared, it causes the inflammation of a jet of hydrogen on the latter being impinged against a small pellet of it. By great pressure spongy platinum is condensed into laminæ having the metallic lustre.

Platinum black differs from spongy platinum, not only in colour, but in being perfectly amorphous. It is also in a still finer state of division, and possesses in the highest degree the power of condensing gases upon its surface and of inducing the combustion of gases and vapours. It is prepared by adding to bichloride of platinum, first protosulphate of iron, then caustic soda, and afterwards hydrochloric acid; or by precipitation from the chloride by means of metallic iron reduced by hydrogen from the oxide obtained on igniting the oxalate of iron.

Alloys of platinum.—Platinum forms an alloy with tin, which crystallises in cubes, and contains Pt_2Sn_3. With twenty-five per cent. of iridium, or with nineteen and a half per cent. of iridium and five per cent., of rhodium, platinum forms alloys that are perfectly malleable: they may be worked into vessels that are almost unacted upon by aqua regia, and which, from their greatly increased rigidity, retain their shape longer and better than if constructed of platinum alone.

Detection of platinum.—The production of the yellow crystalline precipitate with chloride of ammonium, which becomes converted into a spongy metal on ignition, is sufficiently characteristic of platinum.

Estimation of platinum.—This may be effected in the state of spongy platinum produced as already directed; or, on a tared filter, as ammonio-chloride of platinum which contains 44·28 per cent. of metal; or as potassio-chloride which contains 40·43 per cent. of platinum.

PLATINUM BLACK. [PLATINUM.]

PLATINUM, *inflammable chloride of.* Ethylchloroplatinic acid. [ETHYL.]

PLATINOPYRIDINE. [PYRIDINE.]

PLATOSAMINE. [PLATINUM.]

PLATOSOPYRIDINE. [PYRIDINE.]

PLAYHOUSE. [THEATRE.]

PLEA. [PLEADING.]

PLEADING at Common Law. Pleadings are the allegations of the respective parties to a cause expressed in technical language. In order that a correct decision may be made upon disputed rights, it is necessary that the points to be decided should be clearly ascertained, and this is effected by the system of pleading, whereby the precise points in controversy are presented for decision, unencumbered with extraneous matter.

Actions are now commenced by writ of summons, calling upon the defendant to *appear*, or otherwise the plaintiff will proceed to judgment and execution. If the defendant fails to appear, the plaintiff obtains a judgment by default. If he appears in court to answer the proceedings against him, he is then entitled to receive from the plaintiff a detailed statement of the nature of his complaint, which is called the declaration, *narratio*, or count, though the last of these terms is now more commonly used to denote one of several distinct matters of complaint comprised in the same declaration.

Eight days after the delivery of the declaration, the time for pleading arrives; the term "pleading" being not only used in the extensive sense mentioned above, but also in the limited sense of the answer, whether consisting of statement or of denial, which is made by the defendant to the declaration. In answering the declaration, the defendant is not allowed to accumulate his objections both of law and of fact in one defensive pleading. The peculiarity of our system in referring matters of fact to the decision of a jury, and of leaving questions of law only to the judges, has created a necessity for separating the matters of law from those of fact, and of presenting the latter in a shape in which they can be readily understood by persons who are not lawyers by profession. It is to the severe analysis required by this feature of our jurisprudence that the system of pleading is probably indebted for its excellence.

If, when called upon to plead, the defendant fails to do so, he is supposed to admit the complaint set out in the declaration, and therefore the court pronounces judgment against him upon his default, or, as it is termed, by *nil dicit*, those being the words by which the default of a defendant was formerly recorded. He may, however, decline to answer the charge contained in the declaration, on the ground that the court has no jurisdiction of the matter; or that the plaintiff is not entitled to sue, as being an outlaw, foreign enemy, or the like; or that the defendant cannot be sued alone, as being a married woman, or as a party to a contract which forms the subject of the action, that he is sued without his co-contractor being made a co-defendant in the action. This is called *pleading in abatement*, because the defendant prays that the court will abate (put down) or quash the proceedings. The defendant may also pass by these pleas, and admitting, for the present purpose at least, that the facts stated in the declaration are true, may insist that the facts give the plaintiff no cause of action against him; he may accordingly rest (demur) upon the facts as they appear in the declaration, and call upon the court to give judgment in his favour upon that state of facts. This form of pleading is called a "*demurrer.*" Or, finally, the defendant may answer the complaint, or, as it is technically called, he may "plead to the action;" and that in one of two ways: he may deny one or more of the material allegations in the declaration which is necessary to the maintenance of the action: or plead one sweeping denial of the whole declaration, which is called pleading the "*general issue;*"—which pleas are supposed to "conclude to the country," that is, the defendant in them states his readiness to submit to the decision of a jury (who are called "the country," as contradistinguished from the "court") the truth of the matter of fact asserted in the declaration and denied in the plea. It is the same if the plea asserts a fact denied in the declaration; and in either case the defendant is said to *take issue.*

Another mode of "pleading to the action," is by putting in a "*special plea,*" which either expressly, or, according to modern practice, tacitly, admits the truth of the allegations contained in the declaration, but which not only confesses but also avoids them. The special plea (whence the whole system is often called "special pleading") introduces some new fact or facts, the effect of which, if true, is to show that notwithstanding the facts alleged in the declaration, the plaintiff is not entitled to maintain his action. As it is yet uncertain whether the plaintiff will deny this new matter or will admit it to be true, there can be no conclusion to the country upon such a plea, but if that new matter contain an affirmative proposition, the defendant is supposed to conclude his plea with a *verification*, that is, an offer to prove it if its truth should be controverted on the other side. This is called "tendering an issue."

This special plea may also consist of those facts, on which a court of equity would relieve the defendant against the plaintiff's claim, and is thence called an *equitable defence.*

The next pleading on the part of the plaintiff will be regulated by the course pursued by the defendant. If the defendant has pleaded in abatement, the plaintiff either acquiesces in the action being quashed, or he demurs to the plea as not showing sufficient matter for quashing the proceedings, or he replies to the plea either by taking issue (denying) some material allegation in the plea, or by confessing and avoiding the plea, alleging some matter which, consistently with the truth of the plea, destroys its effect and shows that the proceedings ought not to be quashed, or amends his proceedings. If the plaintiff demurs to the plea in abatement, the defendant must either abandon that plea and put in a plea to the action, or he must join in demurrer. If, upon the argument of the demurrer, the court are of opinion that the plea in abatement is good, they give judgment that the proceedings be quashed: if they are of opinion that the plea is bad, the judgment is, that the defendant answer over (quod respondeat ouster), in other words, that he plead to the action.

If the plaintiff take issue upon the plea in abatement, the defendant is bound to join issue, that is, to accept the mode of trial offered, and if upon a trial the issue be found for the defendant, he has judgment that the proceedings be quashed; but if the verdict be for the plaintiff, the judgment is, not that the defendant answer over, but that the plaintiff recover his demand against the defendant.

If the defendant has demurred to the declaration, the plaintiff either abandons the action or he applies to the court for leave to amend his declaration; or he joins in demurrer, asserting that the declaration is sufficient to support the action. This demurrer and joinder form "an issue in law," or a question between the parties to be decided by the court after hearing the matter of law argued on both sides.

The plaintiff's answer to the defendant's plea, whether in abatement or in bar, is called a *replication*. If the defendant has taken issue, by pleading in denial of part or of the whole of the declaration, the plaintiff joins issue. If the defendant has pleaded specially, the plaintiff may either take issue upon the new matter alleged, or he may plead new matter, thus in his turn confessing and avoiding the defendant's plea, doing this by *equitable replication* if the case admits of it. Whenever in the course of the pleading in a cause one party takes a proper issue upon an allegation of his adversary, that adversary is bound to join issue and go to trial before a jury; but when, instead of taking issue, new matter is pleaded, the adversary has the option of taking issue upon that new matter, of confessing and avoiding it, or of demurring to it. As the pleadings may thus go on through several more stages, names have been devised for those which most frequently arise. The defendant's answer to the plaintiff's replication is called a *rejoinder*; the plaintiff's answer to the rejoinder is called a *surrejoinder;* the defendant's answer to the surrejoinder is a *rebutter;* and the plaintiff's answer to the rebutter is a *surrebutter*. The proceedings might go on ad infinitum, but for a very salutary rule which forbids a party from alleging anything inconsistent with, or even not corroborative of, his previous pleading. A violation of this rule is called "*a departure in pleading*," and if not amended is attended with fatal consequences to the party guilty of it.

The above is a short and necessarily incomplete sketch of the course of pleading at common law, without defining the strict rules by which the altercations between the parties are carried on, the object of which is to develope the precise points in controversy between parties, and to present them in the most convenient shape for decision. Of these rules Lord Mansfield observes: "The substantial rules of pleading are founded in strong sense and in the soundest and closest logic, and so appear when well understood and explained; but by being misunderstood and misapplied, are often made use of as instruments of chicane." The object of most of the new rules of pleading has been to prevent this misapplication as well as to lessen expense, though, as might be expected, in order to avoid an evil practically felt, restrictions have been introduced which are found to be productive of as much inconvenience as that sought to be remedied.

Where a point is raised which is found to consist wholly or principally of matter of fact, the parties, provided there has been a correct application of the rules of special pleading, are distinctly apprised by the pleadings of the exact nature of the question to be decided by a jury, and are thus enabled to direct their attention to that question, and prepare their proofs with reference to that question only. If the point in controversy is found to resolve itself into a question of law, a decision may be obtained by submitting the matter to the opinion of the court after argument upon demurrer, without the trouble, expense, and hazard of a trial before a jury.

We possess very little information as to the mode of pleading previous to the Conquest. At or soon after that period an important revolution took place. The pleadings in the Aula Regia, and afterwards in the courts which branched out of it, appear to have been conducted vivâ voce in the French language, by Norman advocates called "countours." After a discussion before the court as to the proper form of pleading [SERJEANTS], the pleadings were minuted down by the officers of the court in the form in which they had been finally agreed upon. Thus, little or no inconvenience arose from the prohibition which existed against the making of any alteration in the pleadings after they were entered. In the reign of Edward III. the pleadings were directed to be carried on in English, and the entries of these pleadings to be in Latin. Afterwards a custom was introduced of preparing the pleadings out of court and delivering them to the officers to be entered. In consequence of this arrangement defects in pleadings were not discovered until a period at which the parties were bound by them as being entered, and it became necessary for the legislature to interfere in order to allow amendments to be made in some cases, and in others to direct the judges to pronounce judgment without regard to formal objections. By the late rules all pleadings must be *delivered* by the one party to the other. ('Blackstone's Com.' Mr. Kerr's ed., vol. iii., *passim.*)

PLEADING IN EQUITY. The following remarks may serve to show how far Pleadings in Equity differ from Pleadings at Law, from which they are derived; and they may be taken as supplemental to the article EQUITY, in which a reference is made to this article.

The Answer in Equity differs materially from the answer at Law, in being upon oath, except in the case of persons who have privilege of peerage, or are Quakers or Moravians, and in the case of a corporation; and the plaintiff may use the whole of the defendant's answer as evidence against him at the hearing of the cause, or such integral part of it as he may think proper. He may also, by means of the admissions contained in the answer, obtain the inspection of books, papers, and writings in the defendant's possession, which support his (the plaintiff's) claim, and he may use them as evidence at the hearing of the cause. The defendant, except on the question of costs, can make no use of his own answer, further than as showing what his defence is; and he must support this defence by evidence, just in the same way as the plaintiff must prove those parts of his case which he cannot prove by the admissions in the defendant's answer. Any number of plaintiffs may join in a suit, if they have all a common interest, however unequal in value, in the subject-matter of the suit; and a common interest means such a legal or equitable title to the subject-matter of the suit, or to some part of it, as will entitle them to a decree which shall affect the defendants. All the plaintiffs in a suit are considered one, as appears from the general rule that a suit is abated by the death of a plaintiff or the marriage of a female plaintiff; and also from the rule that a person who has no interest in the subject of the suit cannot join as a plaintiff with one who has. But the suit is a different suit against each defendant, for each defendant may answer separately to the bill; and no defendant is affected in any way by the answer of a co-defendant. If a defendant dies, the suit abates as to him, but continues as to the other defendants, though it is nearly always necessary to restore the integrity of the suit by making the personal representative or the heir at law of the deceased defendant a party to it.

The writ of Subpœna was until recently the original process by which a party was brought before the court. This writ required the person to whom it was addressed to appear and answer "upon pain of an attachment issuing against his person, and such other process for contempt as the court should award." Those who had privilege of peerage were required to appear and answer by a Letter Missive from the lord chancellor. The act 15 & 16. Vict. c. 86, substitutes the service of a copy of the bill upon the defendant for the old process.

The bill is briefly and sufficiently defined to be "a declaration in writing, showing the plaintifes griefe, and the wrong which he supposeth to bee done unto him by the defendant, and what damages he sustaineth by occasion thereof, praying process against him for redresse of the same." (West, 'Simboleography,' 194, ed. 1622.) "And first the matter of every bill ought to be true. Secondarily, the same matter ought to be laid down therein plainly and certainly in every circumstance of the thing, person, time, place, manner of doing, and other accidents. And thirdly, the same ought to be sufficient in law, both for the forme thereof, and for the matter, that it be such as is examinable in this court; which being otherwise, may be dismissed thence." (West.)

A bill then is a declaration in writing of a complainant, or of several complainants who have such a common interest as may form the subject of one suit. Like a declaration at law, it contains the claim of the plaintiff and the grounds thereof. In form it is, as already observed, a petition or supplication: as it commences with words of supplication, so it concludes with a prayer for relief.

According to present practice, a bill has become a much longer declaration than formerly, which is partly owing to the more complicated nature of modern transactions, and partly to other causes. It is divided into various parts by modern writers, but in effect it only contains two parts, the declaration of the grievance and the prayer for relief. The declaration consists of what are technically called Statements and Charges; the statements are or ought to be a clear exposition of the facts on which the plaintiff founds his title to relief; and every fact which is necessary, either by itself or coupled with other facts, to support the plaintiff's prayer, should be sufficiently alleged. This rule, though it may appear vague, and would be useless to any person who attempted to draw a bill without experience in such matters, really contains all that can be said in general terms. The recent Chancery Amendment Act directs that "every bill shall contain as concisely as may be a narrative of the material facts, matters, and circumstances, on which the plaintiff relies, such narrative being divided into paragraphs numbered consecutively, and each paragraph containing, as nearly as may be, a separate and distinct statement or allegation, and shall pray specifically for the relief which the plaintiff may consider himself entitled to, and for general relief."

The statements of a bill may be followed by charges, which the above enactment does not forbid, and which are not a mere repetition of the statements, but contain certain things or facts either already stated and alleged in the charges with more particularity for the purpose of obtaining an admission from the defendant, or they contain new facts of which in like manner the plaintiff wishes to obtain an admission as evidence in support of his statement and his prayer for relief. It is also usual in the charges to suggest the defendant's grounds of defence, for the purpose of ascertaining what they are, and generally to make all such charges as, if admitted or proved, would sustain the plaintiff's claim against the defendant. Another object is to discover what defence the defendant will make. But the main purpose of the charges is to obtain from the defendant what is technically called discovery, that is, evidence in support of the plaintiff's claim, either by the admissions in the defendant's answer, or from written papers in the possession or power of the defendant. This is the great distinction in present practice between a declaration at law and a bill in equity. Both state the plaintiff's demand and the foundation of it; but the bill in equity also contains a large part of what, if proved, would be the plaintiff's evidence. Now much of this matter which is charged in a bill may be and often is entirely false, and is invented by the plaintiff for the purpose of seeing whether he cannot extract some evidence favourable to himself from the defendant. The plaintiff may invent or suggest as much false matter as he pleases, but it must be matter of that kind, which, if true, would give him a right to that which he demands of or against the defendant. Now the defendant must, if required, answer all that the plaintiff distinctly alleges in his bill, provided it be material to the plaintiff's case, or he must demur or plead to it; and he cannot demur, in the case supposed, because he thereby admits the plaintiff's case to be true, and therefore he must admit that the plaintiff is entitled to the relief which he prays. Thus the plaintiff, by means of the right which he has to compel an answer, incidentally may obtain the discovery, that is, the evidence, which he wishes to have. If the defendant can plead to the bill, he is not bound to answer beyond the plea; for a good plea is a complete answer to the whole bill, or to such part of the bill as it extends to.

Formerly, the charging part of a bill was followed by interrogatories, in which the whole of the matter stated and charged was repeated, and the defendant called upon to say yes or no, or give some explanation to every item. The recent Act has forbidden the insertion of interrogatories in the bill, and the plaintiff, if his bill be such as requires an answer, must file interrogatories for the examination of the defendants separately. The defendant need not answer except thus called upon, he may however do so spontaneously if he chooses.

"An answer is that which the defendant pleadeth or saith in barre to avoid the plaintiff's bill or action, either by confession and avoiding, or by denying and traversing the material parts thereof." (West, 194.) Thus it appears that an answer in equity is in form the same as a plea to the action at law. It must be a complete answer to everything sufficiently alleged and charged in the bill, at least to everything that is material to the plaintiff's claim. By the recent Act it is enacted, that "the answer may contain not only the answer of the defendant to the interrogatories, but such statements material to the case as the defendant may think it necessary or advisable to set forth therein, and such answer shall be divided into paragraphs numbered consecutively, each paragraph containing as nearly as may be, a separate and distinct allegation."

A defendant, as already observed, must in proper form and in due time, as prescribed by the rules of the court, answer the interrogatories upon oath, unless he has privilege of peerage, or be a Quaker, or other person who is excused from taking an oath, in which case his statement on honour in the case of those who have privilege of peerage, and in the other case his solemn affirmation, is sufficient. But the plaintiff may consent to take the answer without the defendant's oath or signature, which is sometimes done. Those who are not Christians must swear to the truth of their answer in such form as the religion which they profess declares to be a binding form.

A plaintiff may by leave of the court amend his bill either before answer or after; that is, he may strike out parts and insert new parts; and it is not easy to say what are the limits to the amount of alteration. A defendant is rarely permitted to amend his answer.

A demurrer in equity needs little explanation further than what has been given. [EQUITY.] When it is a demurrer to the whole bill, which is the most usual kind of demurrer, the object generally is to get rid of the suit, and to avoid an answer which may give the plaintiff some discovery. If the demurrer is allowed, the suit is properly at an end; but leave is often given to the plaintiff to amend his bill, particularly where the demurrer is for want of proper parties. If the demurrer is overruled, the suit proceeds.

A plea in equity may require a few words of explanation. A plea in bar to the whole bill, which is the common kind of plea, is an averment which is offered as a substantial answer to all the statements and charges in the bill, though it is not in form such an answer. In fact, a plea in equity is the same thing as a plea at law: it is the defendant's answer to the whole of what is adversely alleged, and as it does not in terms answer all that is adversely alleged, it must be taken to admit that to be true which it does not in terms answer, because the averments of the plea are offered as a complete answer to the bill. In the old books there is no distinction made between a plea in equity and an answer in equity; nor is there any difference substantially. "A plea is a special answer to a bill, differing in this from an answer in the common form, as it demands the judgment of the court in the first instance whether the matter urged by it does not debar the plaintiff from his title to that answer which the bill requires." (Lord Redesdale, in *Roche* v. *Morgell*, 2 S. and L., p. 724.) Now, as a complete answer is that which the plaintiff requires, and is entitled to if his bill is good in substance and form, and as discovery is in many cases his chief object, and in some cases his only object, it is evident that before any further proceedings can be taken in the matter of a bill to which a defendant pleads, it must be determined whether the plea is good in form: and for this purpose the averments of the plea must be considered as true; and all that part of the bill must also be considered as true to which the plea is no direct answer.

Now, the plea is good in form if it contains averments which either directly negative all the allegations in the bill that give the plaintiff a title to relief against the defendant, or positive averments which destroy the effect of such allegations. The plea is bad in form if the averments of the plea, though true (as on arguing the formal goodness of the plea they are assumed to be), are not a complete answer either by negation or affirmation or both, to all the allegations in the bill which give the plaintiff a title to that which he demands of or against the defendant. The formal badness of such plea is a necessary consequence of the admitted truth of all those parts of the bill to which the averments of the plea do not extend. In order therefore that a plea may be taken as a sufficient answer to the whole bill, it must contains sufficient averments to negative or displace all the allegations in the bill which, if true, gave the plaintiff a title to relief. But inasmuch as a plea is an answer, the defendant must, in addition to the averments, give an answer upon oath to all those statements and charges in the bill upon which he is interrogated, which, if true, would destroy the effect of the matter pleaded; and this is called supporting a plea by an answer, which is generally necessary. If the plea is decided to be good in form, then the truth of the plea alone is in issue between the plaintiff and defendant, and the cause is heard on the issues so joined: just as, in the case where the bill is answered, the cause is heard upon all the issues of law and fact joined by such bill and answer. If a plea is simply overruled, the defendant must answer the bill. If it is overruled, the answer in support of the plea, if there is one, may serve for an answer as far as it goes, and the court may accordingly order it to stand for an answer to such part of the bill, with liberty to except to it or not, according as it may be an insufficient or sufficient answer to that part of the bill to which it extends.

The matter pleaded as an answer to the bill must be one thing, and such a thing as is an answer to the whole of the plaintiff's demand, or to so much of the bill as the plea extends to. The defendant cannot, according to the rules of equity pleading, plead in bar several and distinct matters, any one of which would be an answer to the bill. But if the averments are averments of separate facts which form one material fact, such averments make a good plea; which is thus expressed by Lord Eldon:—"The office of a plea generally is not to deny the equity, but to bring forward a fact which, if true, displaces it: not a single averment, as the averment in this answer, that no bill of sale was executed, but perhaps a series of circumstances forming in their combined result one fact which displaces the equity" (Lord Eldon, *Rowe* v. *Teed*, 15 Ve. 377).

The definition of a plea "not denying the equity, but bringing forward a fact which, if true, displaces it," is in substance the same as the definition of an exceptio by Gaius (iv. 119):—"Omnes exceptiones in contrarium concipiuntur, quia adfirmat is, cum quo agitur."

A defendant may disclaim all interest, right, or title in or to the matter of the plaintiff's bill; but it will nearly always happen that such disclaimer will be an insufficient answer by itself, and that there will be parts of the bill to which it will be necessary to give an answer.

A defendant may demur to a part of a bill as well as to the whole bill: he may also plead to a part of a bill as well as to the whole bill: and he may demur, plead, answer, and disclain, with respect to the same bill. But it is very rare that any two of these ways of pleading are united, except an answer and disclaimer, on account of the practical difficulty attendant on such a mode of defence. For it follows from the nature of these ways of pleading that they must severally apply to substantially different parts of the bill. A man cannot plead to that matter to which he demurs; for to plead is to offer something as an answer sufficient in substance, though it may not be so in form, and to demur is to allege that he ought not to answer. For the same reason he cannot answer, in the formal manner of an answer, to that to which he has either pleaded or demurred, having by pleading already offered something as a sufficient answer, and having by demurrer alleged that he ought not to answer. "A plea or answer will therefore overrule a demurrer, and an answer a plea; and if a disclaimer and answer are inconsistent, the matter will be taken most strongly against the defendant upon the disclaimer." (Mitford, p. 320.)

Pleadings in equity were formerly continued, like pleadings at law, beyond the bill and answer. The plaintiff replied to the defendant's answer by his replication, which is defined to be "the plaintife's speech or answer to the defendant's answer, which must affirm and pursue his bill, and confesse and avoid, denie or traverse the defendant's answer." (West.) Thus if the answer denied the plaintiff's claim as stated in the bill, and suggested or stated some new matter, it was necessary for the plaintiff to make a special reply which was analogous to the defendant's answer. To meet this special replication, the defendant put in a rejoinder, which is defined to be "the answer which the defendant maketh to the plaintif's replication, which must pursue and confirm his answer and not swarve from the same, and sufficiently confesse and avoid, denie or traverse each material part of the plaintif's replication. If the parties be not at issue by reason of some new matter disclosed in the defendant's rejoynder that requireth answer, then may the plaintif surrejoyne to the said rejoynder, and the defendant in like manner to the surrejoynder, if there be cause, which hapneth verie seldome." (West.)

This method of pleading by special replications and rejoinders is now disused, and all the objects of such proceedings are at present attained by the power which the plaintiff has of amending his bill and stating his case in a better form after he has seen the defendant's answer. The disuse of special replications has also led to the practice of frequently stating the plaintiff's case more completely in his bill in the first instance, and introducing numerous charges and suggestions. Thus if the plaintiff anticipates that the defendant may plead to his bill, and so prevent him from obtaining the complete answer which he wishes, he will charge various matters in his bill which will destroy the effect of the anticipated plea, unless the defendant supports his plea by a full answer to such matters.

According to recent practice the plaintiff may at any time after the time allowed for answering has expired, move the court for a decree, in which he relies entirely upon the admissions in the answer to substantiate his own case. If the answer is against him, he must file a replication, by which he joins issue with the defendant, and both sides are at liberty at once to go into evidence to support their several cases.

The form of pleading used in this country is derived from that of the Romans. In Bracton's work, the fifth part, which is entitled 'De Exceptionibus,' occupies the same place in his treatise as the same matter does in the Institutes of Gaius and of Justinian, and the terms used by Bracton are those of the Roman law: indeed, the whole work of Bracton follows the method and order of Justinian's Institutes. A comparison between the Roman and English procedure in equity is made in Gilbert's 'Forum Romanum.'

After the Legis Actiones among the Romans fell into disuse, the mode of procedure was per formulas, the nature of which is fully explained by Gaius (iv. 39, &c.). The Demonstratio was that part of the formula which showed the matter upon which the plaintiff's demand was founded; the Intentio contained the demand; the Adjudicatio gave power to a judex to decide on the matters in dispute; and the Condemnatio empowered him to make a decree in favour of the plaintiff, or to dismiss the defendant, according to the evidence produced before him. The formula was a proceeding in jure, that is, before the prætor, and it contained the instructions to the judex, to whom, according to Roman practice, the investigation of the facts and the ministerial duty of pronouncing the decree were entrusted. The answer of the defendant to the plaintiff's claim was called Exceptio, and exceptiones were either peremptoriæ—in the bar, or dilatoriæ—in abatement. The plaintiff might answer the defendant's plea by his Replicatio, and the defendant might answer the Replicatio by a Duplicatio, to which the plaintiff might answer by a Triplicatio; "and the practice of all such pleadings," says Gaius (iv. 129), "has been sometimes carried even farther than this, owing to the multifarious character of the matters in dispute."

One example may be sufficient as an instance of the Roman pleading. "If an argentarius sue for the price of a thing sold by public auction, the form of the defendant's plea may be a submission to have judgment against him, provided (si) the thing which was purchased has been delivered to him; and this is a good plea (exceptio). But if the conditions of sale were that there should be no delivery till the money was paid, the argentarius may put in a replication to this effect, submitting to the plea, unless (nisi) the conditions of sale were that the thing should not be delivered to the purchaser before he had paid the money" (iv. 126). The words *si* and *nisi*, which are used in this passage, were introduced merely for the purpose of adapting the pleadings for insertion in the formula; for the Condemnatio in the formula was conditional; that is, if so and so is proved, then make such and such a decree against the defendant; and if not proved, dismiss the defendant.

PLEDGE is a thing bailed (delivered for a temporary purpose [Bailment]) as a security to the bailee for the performance of some engagement on the part of the bailor. When the pledge is for a debt, more especially where it is given to secure a loan at interest, it is commonly called a pawn. [Pawnbroker.] In bailments the degree of care required from the bailee varies according to circumstances. When the bailment is for the sole benefit of the bailee, he is bound to use the greatest care, and is excused by nothing but unavoidable accident or irresistible force. When the bailment is for the mutual benefit of bailor and bailee, the latter is bound to take the same care of the thing bailed as a prudent man usually does of his own. When the bailment is for the sole benefit of the bailor, it is sufficient if the bailee keep the goods bailed as carefully as he does his own, however negligent he may be. Different writers on the law of bailments refer the contract of pledge to each of these divisions.

The pledgee is bound to return the pledge and its increments, if any, upon being requested so to do, after the performance of the engagement. This duty is extinguished if the pledge has ceased to exist by some cause for which the pledgee is not answerable. But he is responsible for all losses and accidents which happen after he has done anything inconsistent with his duty as pledgee, or has refused to do his duty. When the full amount of the debt or duty therefore is tendered and refused, and the pledge is detained, the pledge is at the sole risk of the pledgee: so if the pledgee misuse the pledge. In every case where the pledge has sustained injury from the wrongful act or default of the pledgee, the owner may recover damages to the amount of the injury, in an action on the case. By the act of pledging, the pledgor impliedly warrants that the property is his own, and such as he can rightfully pledge.

The contract of pledge may be extinguished by the performance of the engagement for which the pledge was given, or by satisfying the engagement in any other manner, either in fact or by operation of law, as by the acceptance of a higher security without an express stipulation that the pledge shall continue.

If the engagement, to protect which the pledge is given, be not performed within the stipulated time, the pledgee may sell, upon giving due notice to the pledgor. If no time be stipulated, the pledgee may give notice that he requires a prompt fulfilment of the engagement, upon non-compliance with which he may sell.

The possession of the pledge does not affect the right of the pledgee to enforce performance of the engagement, unless there be a special agreement, by which he has engaged to resort to the pledge only, or to look to it in the first instance.

Though the pledgee may sell, he cannot appropriate the pledge to himself upon the default of the pledgor; nor is he at liberty to use it without the permission of the owner, expressed or clearly implied. Such an implication arises where the article is of a nature to be benefited by or to require being used, in which latter case the use is not only justifiable but indispensable to the discharge of the duty of the pledgee. (Story's 'Commentaries on Law of Bailment.')

As to the power of an agent to pledge, see Agent; and Factor.

PLEDGE (Roman). This word formerly denoted a person who was a security for another; but it now denotes a thing which is a security, and generally for a debt.

The chief rules of English law as to mortgaging and pledging are derived from the Roman law, in which however there is no distinction among pledges, dependent on the nature of the thing pledged, whether it was a thing moveable or immoveable, corporeal or incorporeal; and a thing could not be the subject of pledge unless it could be the subject of buying and selling, for the power of selling a pledge was an important part of the creditor's security. A man might pledge a thing either for his own or another person's debt. The terms used in the Roman law to express pledging, and also the thing pledged, are Pignus and Hypotheca. It is properly hypotheca, where there is a bare agreement (nuda conventio) that a thing shall be a security to a creditor for a debt, and the thing remains in the possession of the debtor. The word hypotheca (ὑποθήκη) is Greek, and denotes a thing subjected to a claim or demand. When the thing was delivered to the creditor, it was called Pignus (Isid., 'Orig.,' v., c. 25); and as moveable things would for obvious reasons be most frequently delivered, a notion got established among some Roman lawyers, aided by an absurd etymology (pignus appellatum à pugno, 'Dig.,' 50, tit. 16, s. 238), that the term pignus was applicable only to a pledge of moveable things; and this notion has also prevailed in modern times. The true etymology of pignus seems to be the same as that of pactum. It is generally said that hypotheca corresponds to the English mortgage, and pignus to pawn or pledge; but this is not the case. No ownership was transferred by the Roman hypotheca. The term hypothecation in English law is still used to express the mortgage of a ship or its cargo.

After the time agreed on for payment was passed, the creditor had the right of selling the pledge and of retaining his debt out of the produce of the sale. If the produce of the sale was not sufficient to discharge the debt, he had a personal action against the debtor for the remainder. Originally perhaps he could only have this right of sale by express contract, but subsequently the right to sell (jus distrahendi sive vendendi) was an essential part of the contract of pledge. Though the creditor was not the owner of the thing (dominus), still he could transfer ownership to the purchaser, a doctrine that is only intelligible on the supposition that he sold it as the attorney or agent of the debtor. But the creditor could only sell the thing in respect of the debt for which the thing was pledged, and not in respect of other debts due to him from the debtor, though he might apparently retain the surplus of the sale in his hands as a satisfaction for such other debts. The power of sale was to be exercised pursuant to the terms of the contract; and when there was no agreement as to the form and manner of sale, the law prescribed the mode of proceeding, which the creditor was bound to observe strictly. It was once usual to insert in the contract of pledge a Lex Commissoria, that is, a condition by virtue of which the thing pledged became the absolute property of the creditor, if the money was not paid at the time agreed on. But by a constitution of Constantine ('Cod.', viii., tit. 35) it was forbidden to insert such a clause in the contract. If anything remained over after satisfying the creditor, it belonged to the debtor.

As the pledgor remained the owner of the thing pledged, he could of course sell it, but the purchaser took it subject to the pledge. The creditor who was in possession of a pledge was answerable for any damage that befel it owing to dolus or culpa, that is, fraud or neglect, but he was not answerable for unavoidable loss.

A pledge was determined in various ways; by the destruction of the thing, by the creditor releasing the debtor, by the debtor paying the debt, and in other ways. When the debtor offered the money to his creditor, he was entitled to have the pledge restored to him. This might be obtained by an actio pignoraticia, which was an actio in personam, and also lay for damages done to or sustained by the thing, or for the surplus of the money if the pledge had been sold by the creditor. The creditor had a contraria pignoraticia actio against the debtor for expenses incurred as to the pledge, for any fraud in the matter of the pledge, as passing off base for better metal, and in some other cases.

The Roman law of pledges has been treated by various writers at great length. A compendious view of it is contained in Brinkmann's 'Institutiones Juris Romani,' Slesvici, 1822; in Marezoll, 'Lehrbuch der Instit. des Röm. Rechtes,' Leipzig, 1839; and in Ayliffe's 'Law of Pledges or Pawns,' London, 1732.

PLEDGING, CUSTOM OF, derived from the French *pleige*, a surety or gage. The expression "I'll pledge you," in drinking, is deduced by some of our writers on popular antiquities from the times when the Danes were in possession of England. It is said to have been the custom of that people to seize the moment when a native of the island was in the act of drinking, to stab him with a knife or dagger; whence people could not drink in company unless some one present would be their pledge or surety that they should receive no harm. (Brompton; Sir Richard Baker's 'Chron.;' Henry, 'Hist. Great Brit.:' see also Eric Pontoppidan's 'Gesta et Vestigia Danorum extra Daniam,' vol. ii.)

Others state the custom to have taken rise from the death of King Edward the Martyr, son to Edgar, who, by the contrivance of his step-mother Elfrida, was stabbed in the back as he was drinking.

Brand thought the expression meant no more than that if you took your cup or glass, I *pledge myself to you* that I would follow your example. (Brand's 'Popular Antiquities,' edited by Sir H. Ellis.)

PLEIADES. [Taurus.]

PLENARTY. [Quare Impedit.]

PLENIPOTENTIARY. [Ambassador.]

PLETHORA (a Greek word, πληθώρη, *plethôre*, fulness, in which sense it is used by the Greek medical writers) signifies a redundancy of blood. By the older writers the term was used to express an imagined superabundance of any of the fluids of the body; and the terms, bilious, lymphatic, and milky plethora, &c., implied the existence of an excess of one or other of those fluids in the blood. Distinctions were also made, and by a few are still retained between plethora from excess of blood, from insufficient capacity of the vessels, from deficient strength, and so on. By the majority of the physicians of the present day however, the term plethora is used only to express that condition in which the quantity of blood and its nutritive qualities exceed that standard which is compatible with present or the prospect of continued health.

Plethoric persons are marked by a florid ruddy complexion, a full hard pulse, a tendency to hemorrhage from the nose or other parts, a frequent sensation of fatigue and weight in the limbs, a disposition to sleepiness, and by being in what is commonly termed good condition. In this degree plethora cannot be regarded as more than giving a tendency to disease whenever any slight occasional cause is applied. In a greater degree however, it produces effects which are in themselves important: the complexion is yet fuller and more florid, the face seems swollen, and the eyes blood-shot, there is pain in the head, with giddiness, ringing in the ears, dulness, heavy sleep, and a sensation as of flashes before the eyes, inability of exertion, constant feeling of fatigue, and frequent palpitation of the heart.

Such a condition, to which some persons seem from birth peculiarly predisposed, may be produced in nearly all by the constant use of very nutritious food, by gluttony or excess in beer, by indolence, or by the insufficiency or suppression of some habitual discharge. Its principal evil is that it renders the person who is affected by it peculiarly liable to acute inflammations and to hemorrhages in important organs, as the brain, in which the latter produce apoplexy. To avoid such consequences, a less nutritious diet, abstinence from exciting drinks, and the regular employment of active exercise are commonly sufficient; but in more advanced and in extreme cases of plethora, blood must be drawn freely both from the arm and from the neighbourhood of any organ in which there seems a peculiar disposition to its accumulation, or from which it was once habitually discharged; active aperients should also be administered, and the diet should be reduced to a much lower scale than that which had the chief share in engendering the disorder.

PLEURISY (*Pleuritis*), a word derived immediately from the French *Pleurésie*, which comes from the Greek πλευρῖτις, and this again from πλευρὸν, *the side*, which is defined by Rufus Ephesius ('De Corp. Hum. Part. Appell.,' pp. 30, 51, ed. Clinch) to mean πᾶν τὸ ὑπὸ τῇ μασχάλῃ, "all that part which is under the arm-pit."* As this is one of the diseases of which both the nature and the treatment were understood by the ancients almost as perfectly as by ourselves (except of course that they had not the assistance of auscultation and percussion to help them in forming their diagnosis), it may be as well to give in their own words those passages which have been repeated with more or less alteration by every succeeding writer on the subject, omitting those which are either erroneous from their less accurate knowledge of anatomy, or which rest only upon some fanciful theoretical speculation, and adding whatever may be necessary to bring the article as far as possible up to the level of the present state of medical science.

"Pleurisy, properly so called," says Paulus Ægineta (*loco cit.*, in Mr. Adams's translation, 8vo, London, 1834), "is an inflammation of the membrane which lines the ribs, and is attended with difficulty of breathing, cough, continual fever, and pain shooting to the clavicle and hypochondrium," which definition agrees with that given by Galen ('De Loc. Affec.,' lib. v., cap. 3, p. 326, ed. Kühn; 'Ad. Glauc. de Med. Meth.,' lib. ii., cap. 1, p. 77; 'Introd.,' cap. 13, p. 734; 'Definit. Med.,' § 264), Aretæus, Aëtius, and Alexander Trallianus (*locis cit.*). The disease has been variously divided by different writers; Dr. Good ('Study of Med.') mentions the three following varieties:—1, *Pleuritis vera*, True Pleurisy. Fever, a cauma; pain felt chiefly on one side, the inflammation commencing in that part of the pleura which lines the ribs. 2, *Pleuritis mediastina*, Pleurisy of the Mediastinum. Heavy pain in the middle of the sternum, descending towards its ensiform cartilage; with great anxiety; the inflammation, from its symptoms, being obviously seated in the mediastinum. 3, *Pleuritis diaphragmatica*, Pleurisy of the Diaphragm. Painful constriction around the præcordia; small, quick, laborious breathing; manifesting that the inflammation is seated chiefly in the diaphragm. He adds, however, that the subdivisions lead to nothing of practical importance, as the causes are nearly alike, and the same mode of treatment is applicable to the whole. A more essential distinction is that adopted by Dr. Law ('Cyclop. of Pract. Med.'), namely, acute and chronic, and this will be followed here, because it seems almost impossible to treat either of the nature or the treatment of these two forms of pleurisy under one and the same head.

In acute pleurisy, says Aretæus (*loco cit.*, in Dr. Reynolds's translation, 8vo, London, 1837), "we have acute pain in the clavicular region, together with a sharp burning heat; the recumbent posture is easy on the inflamed side, because there the membrane remains in its place, but to lie on the opposite one is exceedingly painful, and from the weight, inflammation, and dragging, the pain extends through the whole continuity of membrane to the shoulders and clavicles, in some even to the back and shoulder-blades. To this succeed dyspnœa, watchfulness, loathing of food, bright redness of the cheeks, a dry cough, difficult expectoration. To this description it may be added, from Paulus Ægineta, that "the pulse is hard and serrated;" and it should be noticed that the *decubitus*, or position of the patient, mentioned by Aretæus and repeated by numerous modern writers, is not constant, and therefore cannot be exclusively relied upon as a diagnostic sign, for it is sometimes observed that the aggravation of the acute lancinating pain caused by the pressure when lying upon this side, makes the patient seek a more easy position either upon the opposite one or upon the back.

With respect to the diagnosis of pleurisy, it may be distinguished from hepatitis, says Paulus Ægineta, by the pain in pleurisy being pungent, and the cough being sometimes without expectoration and sometimes with it, and by the pulse being hard and serrated; while in inflammation of the liver the pain is not pungent, nor is the pulse so hard, and the cough throughout is dry and without expectoration, and the face appears pale. (Compare Alex. Trall., *loco cit.*) It may be distinguished from inflammation of the external muscles, or pleurodynia [Pleurodynia], by the latter affection being (according to the same author) unaccompanied with cough and expectoration, nor is the pulse hard. From pneumonia it is hard to distinguish it without calling in the aid of auscultation and percussion; and indeed Dr. Cullen, in his 'Practice of Physic,' has treated of both these affections under one common definition. It may however be observed (with Dr. Good) that in pleurisy the face is comparatively but little flushed, and far less tumid than in pneumonia; that the pulse is harder, and that the seat of the pain is fixed, while in pneumonia it shifts not only to different parts of the same side, but often from the one side to the other. The characteristic cough of pleurisy (as distinguished from that which follows pneumonia) is a short cough, either dry from the beginning to the end, or accompanied with a thin mucous expectoration; should the sputa be more abundant, or deviate from this character, we may suspect a complication either of pneumonia or bronchitis. The cough, however (adds Dr. Law), is often wanting altogether, or is so slight as to attract the attention of neither the patient nor physician. For the characteristic signs of pneumonia derived from auscultation and percussion, the reader must see the article Lungs, Disease of the, while only those relating to pleurisy will be given here. Upon auscultation, the inspiration will appear feeble, distant, or inaudible, but will be restored by change of posture. *Ægophony* will exist when the quantity of fluid effused is no more than forms a thin layer between the lungs and parietes of the chest. The *bruit de frottement*, or *sound of friction*, will be heard when there is partial albuminous exudation, with little or no effusion of serum. Upon percussion, there will be more or less of sound, with moderate resistance, decreasing from below upwards; and this dulness will be diminished or removed by change of position. It was in cases of pleuritic effusion that Hippocrates proposed the succussion, or shaking of the chest, as a means of assisting the diagnosis ('De Morb.,' lib. i., p. 173, ed. Kühn; *ibid.*, lib. ii., pp. 256, 258; 'Coac. Prænot.,' p. 306,

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* The word πλευρῖτις is generally said to be derived from πλευρὰ, *the pleura*, but (as far as the writer is aware) the word πλευρὰ is never used by the ancient medical writers in that sense. That which is called *the pleura* by modern anatomists is called ὑπεζωκὼς ὑμὴν, or simply ὑπεζωκὼς by Aretæus ('De Caus. et Sign. Morb. Acut.,' lib. i., cap. 10, p. 20, ed Kühn), Aëtius (lib. viii., cap. 76, p. 175, B., ed Ald.); Alexander Trallianus (lib. vi., cap. 1, p. 85, ed. Steph.), and Paulus Ægineta (lib iii., cap. 33, p. 41, B., ed Ald.). Galen uses the same word in more than one place, and with regard to its meaning says ('De Anatom. Administr.,' lib. 7, cap. 2, p. 591, ed. Kühn), "As the other membrane is called the peritonæum (περιτόναιον), because it is extended around (ἀπὸ τοῦ περιτετάσθαι) the alimentary vessels, so this (that is, *the pleura*) is called ὑπεζωκὼς, because it fastens together internally (ἔσωθεν ὑπέζωκε) the whole of the ribs."

'De Loc. in Hom.,' pp. 123, 124); but it is now known that no sound can be heard unless air be present in the chest at the same time—that is, unless empyema be combined with pneumo-thorax, which is a rare occurrence.

With respect to the anatomical characters of pleurisy, they agree with what may be observed in inflammation of all serous membranes, and consist partly in morbid alterations of the pleura itself, and partly of the secreted fluid. Inflammation of the pleura, says Laennec, is always accompanied by an extravasation on its internal surface; the matter effused being either coagulating lymph termed a *false membrane*, or else serosity, or a sero-purulent fluid. The false membrane, or exudation of lymph, is gradually changed into cellular substance, or rather into a true serous tissue, like that of the pleura. The serous effusion is absorbed, the compressed lung expands, and the false membrane investing it and the pleura costalis become united into one substance, which afterwards becomes vascular and organised, and constitutes permanent adhesions. A severe pleurisy that has terminated by numerous adhesions, renders the part so affected much less liable to subsequent attacks of the same disease; and when it occurs, the inflammation and effusion do not extend to the adherent parts.

Among the occasional causes of pleurisy, enumerated by Laennec (after Celsus), are,—long exposure to cold after violent exercise; metastasis of gout, rheumatism, and cutaneous diseases; blows on the chest; and fracture of the ribs. "The winter season," says Aretæus, "is most liable to produce this disease, and next to it the autumn; the spring is less so, unless it chance to be a cold one, while the summer is the least so of all." In reference to the period of life, he remarks that old people are more liable to it than those who are in the prime of life, and these again than children. Among predisposing causes, Laennec mentions a slender frame, narrowness of the chest, the immoderate use of spirits, and tubercles in the lungs.

Pleurisy terminates either in resolution, suppuration, or gangrene. The former is the ordinary and most favourable issue. The last occurs rarely, and Laennec has seen only one instance of it from acute inflammation. Suppuration, however, is by no means uncommon, in which case, says Aretæus, "shivering fits ensue, and lancinating pains, accompanied with a desire to sit in an upright posture; the breathing gets worse, and there is great fear lest the lung, by suddenly drawing in the purulent matter, should produce suffocation, after the previous and greater danger has been escaped: should the matter, however, burrow between the ribs and separate them, and either point externally or burst into the bowels, the patient usually recovers."

With respect to the treatment, perhaps there is no disease in which profuse bleeding from a large orifice has been so generally recommended by practitioners of all ages and all nations; the only question which has ever arisen upon the subject being, whether the blood should be taken from the side affected, or from the opposite. Hippocrates, and most of the earlier Greeks, recommended the former, while the latter method was practised by Archigenes ('ap. Aëtium,' tetrab, ii., serm. 4, cap. 68), Avicenna ('Canon.,' lib. iii., fen. 10, tract 5, cap. 1), Avenzoar ('Teisir,' lib. i., tract 16, cap. 3, p. 23, D., ed. Venet., 1549), and their followers in the middle ages. The dispute, which is one of those that have been settled by the discovery of the circulation of the blood, was before that time (as may easily be imagined) considered to be of the greatest consequence, and at the beginning of the 16th century raised a kind of civil war (as Bayle says) among the Portuguese physicians on account of the controversy between Denys and Brissot, the particulars of which are too curious to be altogether omitted. The dispute was brought at last before the tribunal of the university of Salamanca, where it was canvassed in a most profound manner by the body of physicians; but in the meantime the partisans of Denys, who were the more powerful, obtained a decree from the civil authorities forbidding physicians to bleed on the same side on which the pleurisy was. At last the university of Salamanca gave judgment, and decided that Brissot's opinion was the pure doctrine of Hippocrates and Galen. The other party removed the cause before the Emperor Charles V., 1529, and were not satisfied with exclaiming against the doctrine of Brissot as false, but declared it to be impious and deadly, and that it was no less pernicious to the body than Luther's schisms to the soul. Unluckily for them, just about this time Charles III., duke of Savoy, happened to die of a pleurisy, after having been bled pursuant to the practice which Brissot had opposed. This put a stop to the appeal to the emperor; but books were written on the question in all parts of Europe, and the practice of the Arabians was generally condemned. A list of these treatises is given by René Moreau, in the Life of Brissot, prefixed to his edition of his work 'De Incisione Venæ in Pleuritide Morbo,' &c., Paris, 1622, 8vo. (See Bayle, art. 'Brissot,' from whom the above account is abridged.) But after all this absurd discussion, there are some cases of pleurisy that will not bear bleeding, and the lancet is now much less had recourse to than formerly.

Besides blood-letting, which may assume the form of cupping and leeches, the usual antiphlogistic remedies, such as saline diuretics, diaphoretics, purgatives, mercurials, blistering, &c., may be employed; in cases of acute pleurisy, the operation of paracentesis thoracis is very seldom had recourse to, and is hardly ever attended with more than a temporary relief.

Chronic pleurisy is either the continuation, as it were, of the disease in its acute form, or else exhibits at no period either the intense fever, the violent pain, or energy of reaction which characterises an acute disease. In this latter form it creeps on very insidiously, without much acceleration of pulse or heat of skin; the pain in the side amounts to no more than a mere soreness; and the difficulty or hurry of breathing is sometimes so inconsiderable as not to attract the individual's attention. However, his unhealthy pallid appearance, his loss of appetite, and languid look, emphatically tell of mischief going on; and upon close examination it is found that the absence of fever is not constant, but that towards evening there is a febrile movement.

The anatomical characters of chronic pleurisy do not differ very widely from those of the acute form, especially when it has been a mere transition of one form of the disease into the other. The fluid effused, however, partakes more of a purulent character, and the false membrane is firmer and more condensed, owing perhaps to the longer time it has been under the pressure of the effused fluid. The lung too is more compressed than in acute pleurisy, so much so that there is sometimes a complete annihilation of its vesicular structure, and the organ itself is reduced to a thin lamina, not exceeding six lines in thickness, lying down along the spine.

The prognosis of chronic pleurisy is, generally speaking, very unpromising: in the ordinary course of the disease a slow wasting fever sets in; there is a gradual emaciation; the appetite fails; the pulse is languid, although not much quickened; the legs swell, and the face becomes puffed; the expectoration often has a disagreeable alliaceous smell. Under these symptoms well-defined hectic fever soon supervenes, and rapidly wears down the patient.

The treatment of chronic pleurisy differs (as might be supposed) very materially from that of the acute form of the disease. Blood-letting is hardly ever resorted to, for the weakened habit of body will not bear the exhaustion of it. For promoting the absorption of the effused fluid, as well as for preventing its further secretion, external applications, comprehending the different modifications of counter-irritation, for example, blisters, setons, issues, stimulating liniments, &c., appear to be most efficacious. In some cases however the operation of paracentesis thoracis seems to be the last resource, and this so often fails that it is by some practitioners considered an almost hopeless experiment. In trying to improve the habit of body and to relieve the constitutional symptoms, which most commonly accompany this form of the disease, recourse must be had to a nutritious but not a heating or exciting diet, and to the cautious exhibition of such tonics as the patient is able to bear. Change of air is often productive of the most decided benefit, and sometimes effects an almost instantaneous amelioration in the symptoms, by causing the night perspirations to cease, the appetite to improve, and the sleep to become refreshing.

(See, besides Good, *Study of Med.*, and Law, art. 'Pleurisy,' in *Cyclop. of Pract. Med.* (from which two works much of this article is abridged), Cruveilhier, art. 'Pleurésie,' in *Dict. de Méd. Prat.*, 1835, and Laennec *On Diseases of the Chest*, translated by Forbes. Besides the ancient authors already quoted, the following references are given by Mr. Adams, in his 'Commentary to Paulus Ægineta:' Celsus, *De Med.*, lib. iv., cap. 6; Psellus *De Vict. Ratione;* Oribasius, *Collecta Medicin.*, lib. ix., cap. 7, 8; Joannes Actuarius, *Meth. Med.*, lib. iv., cap. 4; Theophanes Nonnus, cap. 129; Cælius Aurelianus, *De Morb. Acut.* lib. ii., cap. 13; Octavius Horatianus, *Rer. Med.*, lib. ii. cap. 4; Marcellus Empiricus, *De Medicam.*, cap. 24; Serapion, *Pract.*, ii. 21; Mesue, *De Ægrit. Pect.*, cap. 7; Alsaharavius, *Pract.*, lib. xii., cap. 8; Haly Abbas, *Theor.*, lib. ix., cap. 21; *Pract.*, lib. vi., cap. 13; Rhazes, *Lib. Divis.*, cap. 54; *Contin.*, lib. x.)

A very complete list of works on the subject of Pleurisy is given in Ploucquet, *Literatura Medica Digesta*, 4 vols. 4to, Tübing., 1808-9; and a selection in the Appendix to the *Cyclop. of Pract. Med.*

PLEURITIS. [PLEURISY.]

PLEURODYNIA (from πλευρά, the side, and ὀδύνη, pain—pain of the side), called also "false pleurisy." The term includes all those pains of the sides which are unconnected with pleuritic inflammation, whether arising from a rheumatic affection of the intercostal muscles, neuralgia in the same parts, or any other cause not evidently pleuritic. It is a matter of great importance to distinguish pleurodynia from pleuritis, as the treatment of the one is frequently diametrically opposite to the other. Pleurodynia may arise from a rheumatic or gouty tendency of the body, producing derangement of the respiratory muscles, and in these case the remedies for rheumatism and gout must be applied. When the pain arises from pure neuralgia, the treatment must be adapted accordingly. In hysterical and anæmic cases iron should be given, but in the form of paladal neuralgia, quinine is the great remedy.

PLICA POLONICA is the name given to a disease which is chiefly remarkable for the sticking together and matting of the hair, and which is peculiarly frequent in Poland: a few examples of it have been met with in Tartary, among the lower orders of the Russians, and in Hungary, and fewer still in Switzerland and France.

The disease chiefly affects the scalp; the hair grows to an unusual length, is matted together by a sticky and most offensively-smelling secretion, and is commonly infested with vermin. Indeed, the symptoms of the disease, as far as the hair is concerned, are only those which would result from excessive neglect of cleanliness; and hence many who have seen numerous cases in Poland, believe that they are only produced by the dirty habits of those affected, who, it is well known, if the disease do not spontaneously make its appearance, spare no pains to produce it. So great is the prejudice in favour of Plica entertained by the lower order of Poles, who regard it as affording a certain security from all other sickness and misfortunes, that they will through their whole lives endure the inconvenience and misery of carrying about huge masses of filthy stinking hair many feet in length, rather than submit to the removal of it, which is necessary for their relief.

The hair of persons affected with *Plica Polonica* has been carefully examined under the microscope, and Günsberg and Von Walther have both described the cells of fungi belonging to the genus Trichophyton. The parasite as described by Günsberg consists of articulated filaments surrounded by innumerable spores of very minute size. The changes in the hair produced by this parasite consist in the thickening of the root of the hair, a spindle-like enlargement of the longitudinal cylinder of the channel of the hair, through the constant piling up of new masses of fungi in it, in the splitting and parting of single hair fibres, which gives at last to the hair the appearance of a brush, or of a hedgehog skin, at the point through which the spores of the fungus pass. The epithelium or cells of the hair are very much condensed, and the hair cylinder frequently altogether disappears. In the adhesive mass are found a great many large epithelial cells with small granular bodies, resembling the exudation corpuscles of inflammation. Von Walther attempted to inoculate *Plica Polonica*, but did not succeed.

Herr von Studzienski, a Russian, has recently written on the Plica, and endeavoured to show that it was only an intense form of the natural condition of moulting. This view however is not supported by the facts of the case, and no one can doubt its specially morbid nature, after such researches as those of Von Walther and Günsberg.

The only treatment which is known to be constantly beneficial is the removal of the hair, and strict cleanliness; other means must be decided in each case by the general state of the patient's health. The popular notion entertained in Poland, that dangerous diseases will follow the cutting of the hair, is entirely without foundation.

(Kuchenmeister on *Animal and Vegetable Parasites*, translated by Lankester, 1847.)

PLINTH. [Column.]

PLOMBAGIN. A bitter non-azotised principle of unknown composition, contained in the root of the *Plumbago europæa*. It crystallises in orange-yellow needles of an astringent saccharine taste, volatilises by heat without change, and is slightly soluble in cold water, more so in hot, and readily so in alcohol and ether. Alkalies communicate to the aqueous solution a fine cherry-red colour.

PLOTTING. [Surveying.]

PLOUGH. That the plough is an instrument of the highest antiquity is apparent both from the oldest writings that we possess and from the existing monuments of Egypt. We might exercise our imagination in supposing a probable origin of the plough in the branch of a tree dragged along the ground, in which the stump of a smaller branch made furrows as it went on. It seems indeed probable that some accidental circumstance first suggested this mode of stirring the earth to prepare it for receiving the seed.

The oldest forms of the plough of which we have any description in ancient authors, or which are represented on monuments and coins, are very simple: a mere wedge, with a crooked handle to guide it, and a short beam by which it was drawn, form the whole instrument. The light Hindu plough, now in use in many parts of India, seems to differ little from the old model.

Before we enter into any details it may be as well that we describe the different essential parts of a plough, by the names which are usually given to them.

The body of the plough is that part to which all the other parts are attached. The bottom of it is called the *sole*, or *slade*, to the fore part of which is affixed the *point*, or *share;* the hind part of the sole is called the *heel.* The *beam*, which advances forward from the body, serves to keep the plough in its proper direction, and to the end of it are attached the oxen or horses which are employed to draw it. Fixed in the beam, in a vertical position, before the point of the share, with its point a little forward, is the *coulter*, which serves to cut a vertical section in the ground, while the point of the share, expanding into a *fin*, separates a slice by a horizontal cut from the subsoil or solid ground under it. The *mould-board* or *turn-furrow*, is placed obliquely behind the fin, to the right or left, in order to push aside and turn over the slice of earth which the coulter and share have cut off: it thus leaves a regular furrow wherever the plough has passed, which furrow is intended to be filled up by the slice cut off from the land by the side of it, when the plough returns. The stilts or handles, of which there may be either one or two, as is thought more convenient, direct the plough by keeping it in the line required and at a regular depth in the ground. The single stilt appears to be the most ancient form.

Wheels are a modern invention in comparison with the other parts. They support the end of the beam, and prevent it from going too deep into the ground while the plough is going on. The greatest improvements introduced into modern ploughs are in the shape of the mould-board, or turn-furrow, of which we shall take particular notice, and the contrivances for regulating the line of draught, so as to make the plough go at an equal depth, and cut off a regular slice of equal breadth, without any great force being applied by the ploughman who holds the stilts.

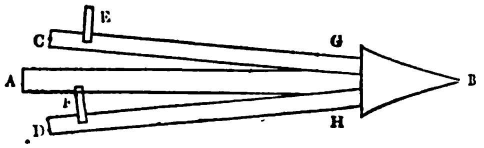
The Hindu plough consists of a slight beam, often without any coulter, a narrow share, and a corresponding stilt. The whole is of wood, slightly pointed with iron. It is so light that a man can readily carry it upon his shoulder. When it is at work it is usually drawn by a small buffalo, and sometimes by a man or a woman. This instrument is intended merely to make a shallow furrow in a very light soil, or in the mud produced by irrigation where rice is cultivated. It does not act as our ploughs do, nor does it turn over a regular furrow, but it acts more like one of the tines, or teeth, of some of our more complicated instruments called cultivators or grubbers, with which the earth is stirred without being turned over.

The Chinese plough resembles the Hindu in its simplicity. The earth is turned over by holding the instrument obliquely, and much depends on the art of the ploughman, in whose hands it is like a stout shovel pulled through the ground by a horse or an ox. The sole is not straight, but rounded, like the bottom of a boat. The work done by this instrument is not unlike the furrow drawn in the sand at the bottom of the sea when a ship drags her anchor.

The ploughs in use in different countries in Europe underwent little change for many centuries; it is only lately that any attempt has been made to vary the old forms.

The Roman plough, such as is described by Virgil in the 'Georgics' (i. 174), is still used in many parts of France, under the name of *Araire Romain.* It consists of a beam (*temo*), a body (*buris*), a share (*vomer*), and a handle or stilt (*stiva*). The office of the turn-furrow is performed by two pieces of wood about six inches long projecting obliquely upwards, and very properly called teeth (*dentalia*) E F (*Fig.* 1). The sole of the plough A B has two pieces of wood C G and D H fixed to it on each side, forming an acute angle with it, in which the teeth are inserted. This exactly answers the description of Virgil, "Duplici aptantur dentalia dorso" (the teeth are fitted to the double back).

Fig. 1.



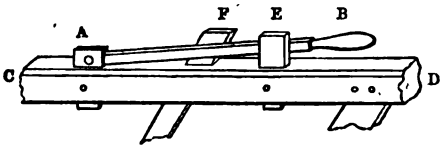
These teeth help to push aside the earth to the right and left, and the instrument resembles what is called a moulding plough, which is used in throwing the soil aside against young plants growing in rows, as turnips, potatoes, &c. A chain or pole connected with the end of the beam was hooked to the middle of the yoke on the neck of the oxen, and thus the plough went on making parallel furrows, so near to each other that the preceding furrow was partially filled with the earth which the dentalia pushed aside. The point was in the shape of the head of a lance. This plough might suffice in light mellow soils, which had been long in cultivation, and had more the texture of garden mould than of stubborn clay.

The small double mould-board plough, common in other parts of France, is evidently taken from this. The teeth not being sufficiently strong, a slanting board was substituted on each side, and wheels were added, to diminish the labour of the ploughman. The stilt remained the same at the place where it is attached to the plough, but higher up it was divided into two, like a fork, for the convenience of holding it with both hands. This plough acts exactly like the other, but it is stronger and better adapted for heavier land. Neither of them goes much deeper than four or five inches, leaving shallow parallel ridges, in which the seed falls, and is buried by light wooden harrows, which are drawn over the land after sowing. This is an imperfect tillage, the bottoms of the furrows being only partially stirred. The broad flat share, and the single mould-board which turns the earth completely over, after lifting it up, is a far more effectual instrument, and has been adopted wherever agriculture has made any improvement. This plough more nearly imitates the digging with a spade; and the more perfect the imitations, the better is the work.

The mould-board of a modern plough is either fixed on one side, or made so as to be shifted from one side to the other. In the first case half the furrow-slices lie on one side and half on the other, and there is of necessity a double furrow where they join. When it is desirable that the surface should be quite flat, and the furrow-slices all in one direction, the mould-board must be shifted at every turn, and a plough which admits of this is called a turn-wrest plough.

It is evident that the mould-board of a turn-wrest plough must be so constructed as to act with either side uppermost; it can therefore have only a very slight convexity to push over the slice cut off by the coulter and share; and a considerable force is lost by the obliquity of the action in doing so. The share of this plough is pointed like a lance, or presents a flat edge like a broad chisel, according as the soil is light or heavy. The point of the coulter is placed in line with that side of the point which is nearest to the unploughed land, and this is done by means of a piece of wood A B (*Fig.* 2), which presses it against one side or the other of the mortice in which it is placed in the beam C D, by changing the position of the pieces A B to the other side of the projection E on the beam, and pressing the head of the coulter F to the other side. The mould-board has a hook at the fore part, which goes into a staple in the side of the fore part of the body of the plough towards the preceding furrow: a piece of wood on the inside of the mould-board keeps it at the proper angle with the line of the sole.

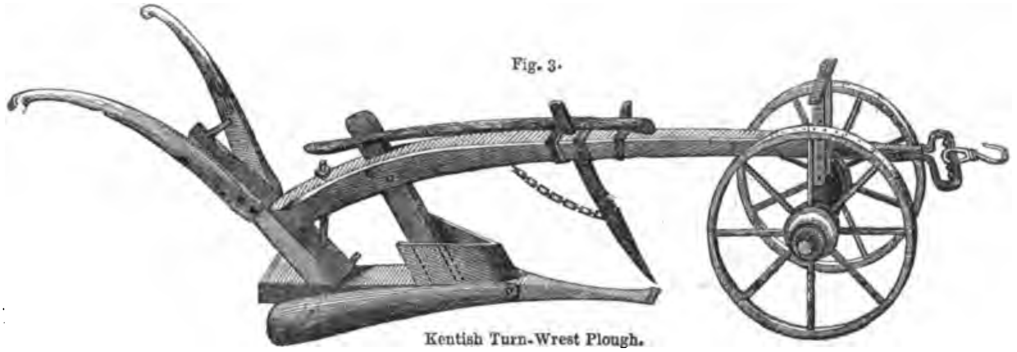
Fig. 2.



The defect of this plough, which is roughly represented below, is in its weight and clumsiness more than in the shape of the mould-board; for when it is made lighter, it is not so bad a construction as appears at first sight, and it does its work very neatly in heavy loams with a dry subsoil. If, instead of one mould-board, two were used alternately, of a better shape for turning over the furrow-slice, this plough would be much improved; and this plan is adopted in many other forms of the turn-wrest plough, as in that made by Cousins, of Southmolton.

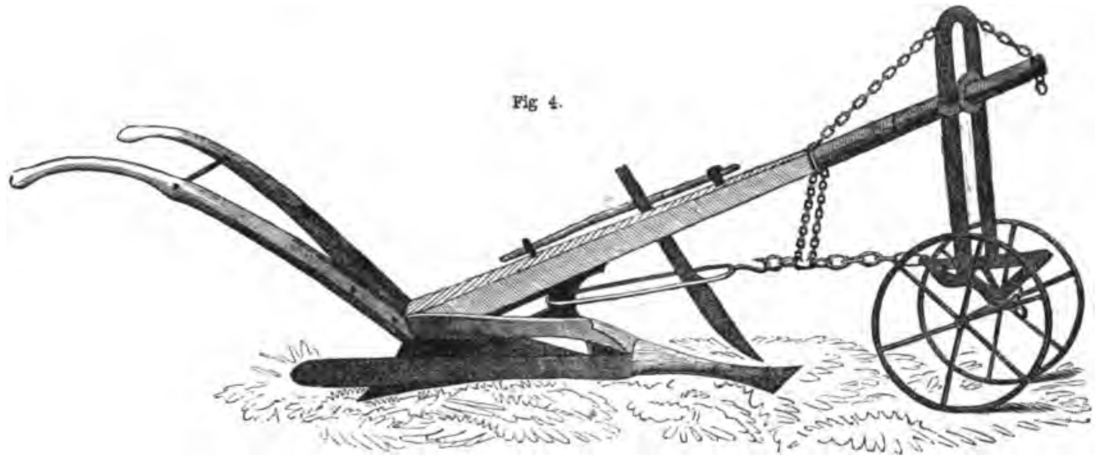
The form of the turn-furrow is of material importance, for on this depends not only the perfection of the work, but also the lightness of the draught. When we follow a plough working in a mellow soil which slightly adheres to the plough, we often perceive that, instead of being turned aside, the earth is carried forward, and only falls off when the accumulation of it becomes heavy enough to overcome the adhesion. It does not slide off from the mould-board itself, but separates from the earth which adheres to the latter; thus showing that the shape is defective, and giving good hints for its improvement. But as the same plough will sometimes turn over the same earth better when it is either drier or moister, it is very difficult to determine, by experiment only, what may, on the whole, be the best shape. A little reflection and the application of scientific principles may greatly assist us here. It is not sufficient however to find the curve which will make the plough go through the ground with the least force. The plough must also perform its work perfectly, and if anything is to be sacrificed, it is better to employ more power than to plough the ground badly. After having ascertained the mechanical principles which bear on the working of the plough, we must observe its action carefully, follow the plough day after day, in different soils and different weather, and thus we may be led to observe all the circumstances which attend its operation, and correct any mistakes which an erroneous theory might have led to.

Fig. 3.



Kentish Turn-Wrest Plough.

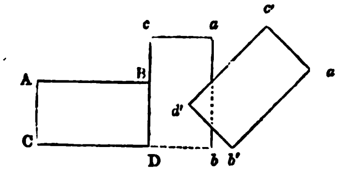
Fig 4.



Ransome's Kentish Turn Wrest Plough.

Many attempts have been made to ascertain the exact curve which the turn-furrow should have to perform the work well and at the same time to produce the least resistance. The difficulty of the problem lies in determining the data, or principles on which the investigation is founded; and these are so various, that it is not surprising that no very satisfactory conclusion has yet been obtained. We will make an attempt at a solution from a simple examination of the motion to be produced in the portion of earth to be turned, which we will call the furrow-slice. We shall suppose this separated from the adjacent soil by the vertical cut of the coulter, and at the same time from the subsoil by the horizontal cut of the share; a section of the slice, by a plane at right angles to the line of the ploughing, will be a parallelogram A B D C (*Fig.* 5), the depth, A C, being the thickness of the slice, and A B its width. Confining our attention to this section of the slice, the object is to move it from its position A B D C, as cut off by the coulter and share, to that of *b′ d′ c′ a′*, where it is inclined at an angle of 45° to the horizontal line; the surface, A B (*b′ a′*), being laid on the slice previously turned over, so as to bury the grass or weeds which might be rooted there, exposing the roots to the sun and air. The more uniformly this motion is produced, and the more regularly the successive sections follow each other, the less power will be required to turn over the whole slice. The motion of C D round the point D must therefore be uniform. If the turn-furrow is horizontal at the point where it joins the share, and of the same width as the furrow-slice, it will slide under the slice; and if the vertical sections of its upper surface, at equal distances from the share, are inclined at angles regularly increasing with this distance till it arrives at the perpendicular, the turn-furrow will, as it advances, turn the slice from a horizontal to a perpendicular position: the section of it will then be D *c a b*. The inclination of the section of the turn-furrow must now be to the other side, forming an obtuse angle with the section of the sole, until it has pushed the slice over at the required inclination of 45°, which theory and experience have shown to be the best adapted to expose the greatest surface to the action of the atmosphere, and likewise to form

Fig. 5.

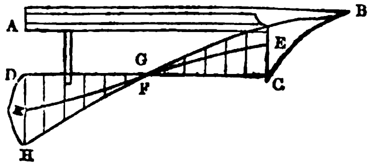


the most regular furrows for the reception of the seed, which the harrow can then most readily bury.

The surface of this turn-furrow is curved in the form of the spiral thread of a screw, such as would be generated by a line (H D in the following figure) about 9 or 10 inches long, and either straight or slightly curved, moved uniformly forward in a direction at right angles to its length, while it revolved uniformly round one of its extremities for 3 or 4 feet, commencing with the horizontal position, and terminating in an angle about 45° beyond the vertical. The curve thus generated will be found to turn over soils of a moderate tenacity very perfectly. If it is very light, the surface may be formed by arcs of circles with a considerable diameter, the concave part upwards; if it is very tenacious, the convex part of the arches may be upwards. The annexed figures (6, 7, 8, 9) will explain this. The distance of the perpendicular F G from the fin of the share may also be varied, either lengthening or shortening the turn-furrow, as experience may show to be most advantageous.

Horizontal Plan of the Plough.

Fig. 6.



A B, the Sole; C, the Fin; D C, the bottom of the Turn-Furrow; K C and H D being the revolving line traversing the distance C D, and shown in its various positions by the transverse lines.

Sections of the three different turn-furrows at different distances from the heel.

Fig. 7.

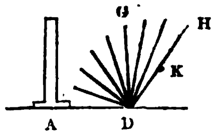


Fig. 8.

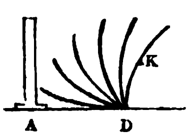
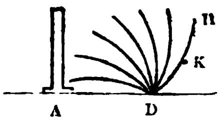


Fig. 9.



A plough was constructed on this principle by Messrs. Ransome, of Ipswich, at the suggestion of the writer of this article (the late Rev. W. Rham), and exhibited at the meeting of the Royal Agricultural Society of England, held at Cambridge, July 15, 1840. In soils of a loose mellow nature it answered completely, and did the work more perfectly than any other plough. It united the parallelism of the sole and bottom of the turn-furrow of the Flemish plough with the improved shape of the turn-furrow. By adopting the variations in the shape of the turn-furrow which we have suggested, this plough may be adapted to any soil, and be used with or without wheels.

Ploughs were formerly made of wood having those parts covered with iron where the greatest friction takes place, the share and coulter only being of iron; but in consequence of the greater facility of casting iron in modern times, it is now made wholly of this metal. The advantages of iron are, its durability, and the smaller friction it occasions when once polished by use. The inconveniences are, the additional weight of the instrument, and consequent greater friction of the sole, which experiments have proved to be greater than was generally suspected. A great improvement has been introduced by making the points of the shares of cast-iron, which, by a mode of casting the lower surface on a plate of metal, makes one surface much harder than the other; and as the softer surface wears more rapidly, a sharp edge is always preserved.

The different parts of a plough are now usually cast, so that if any one fails or wears out, it can be instantly replaced by moving a few screws or bolts. This is a very great saving of time and expense; for before this, every time an accident happened to any part of the plough, it took a long time to repair it, and in the meantime the labour was suspended, often at a very critical time of the year. There is another advantage in having the essential parts of cast-iron. If any particular shape has been once discovered to be the best for any part, that shape is preserved without deviation in every plough made on the same pattern, and with respect to the turn-furrow this is of the greatest importance.

Where the soil is light and crumbling, without stones, as in Norfolk, a single handle or stilt is sufficient; but where some force is occasionally required to prevent stones or other obstacles from turning the plough out of its course, two stilts are most convenient, placed at a more obtuse angle with the sole of the plough.

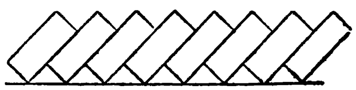
The force required to draw a plough depends not only on the nature of the soil, but also on the shape of the plough, and especially on the position of its different parts with respect to each other, so that they do not counteract each other.

If a plough were drawn in the direction of the sole, the obliquity of the turn-furrow would cause it to turn towards one side, and it would require a considerable force to keep it straight. In order to prevent this, the line of draught is placed at an angle, which varies with that of the turn-furrow and the force required to push the furrow-slice over. To adjust this angle, so as to cause the plough to keep in the intended line, there is a contrivance at the end of the beam to change the position of the ring by which the plough is drawn to the right or left of the line of the beam, and another by which it may be raised or lowered. By this device the plough may be drawn from a point on either side of the beam, and higher or lower as may be required. When the plough is found to *take too much land*, as ploughmen say, that is, tends to increase the width of the slice cut off by the coulter, the bridle is shifted to the left by moving the pin into another hole: when it goes *out of the land*, as it is called, that is, diminishes the width of the furrow-slice, the pin is moved a hole or two to the right, until the plough has no tendency to deviate to either side. If it inclines to rise out of the ground, the ring is shifted in the iron bridle and placed in a hook or notch higher up; if, on the contrary, it dips too deep, the ring is hooked lower. Thus a plough may be made to go straight and at a regular depth, without any more force being applied to the stilts than is required to counteract inequalities in the land, or accidental obstacles, such as stones or roots, which might throw the plough out of the ground. When the soil is of unequal texture, it is useful to have a small wheel connected with the fore part of the beam, so as to prevent its dipping downwards, which would require a great pressure on the stilts to keep the point of the share up, and thus increase the friction of the sole on the ground, and consequently the labour of the horses. In other cases, ploughs are provided with two wheels connected with the beam, one of which runs in the furrow to the right, and the other on the unploughed soil to the left. When the plough has been well adjusted, and the larger wheel runs in the angle of the furrow, it acts as a gauge to regulate the width of the slice as well as its depth: in very uniform soils without stones, the plough, when set in the proper direction, will make a very straight and even furrow parallel to the one in which the wheel runs, without any person holding the stilts; so that all that is required is to turn the plough at the end of each furrow, and set it in to the proper line to form the next. As this admits of very correct adjustment, no unnecessary force is required to draw the plough: and hence this plough appears to be the easiest for the horses; and if the wheels are not very heavy, and the plough is of a good form, it certainly requires less power to move it than many which are without wheels; and it is far superior to the old clumsy wheel-plough, the beam of which rests on a heavy carriage, without being firmly attached to it. This, instead of lessening the draught, increases it by all the pressure of the beam upon the carriage, besides the weight of this last and of the wheels. There are some very irregular and stony soils, where a common swing plough can scarcely be kept steady without the help of wheels, and where it would not be so convenient to have the beam fixed on the wheels. In this case a separate carriage is necessary, that the ploughman may have a fulcrum on which he can raise his plough, or turn it to either side to avoid any considerable stone or other obstacle. Wheels have this advantage: they will enable an inferior ploughman to make better work than he could possibly do without them; and that too with less labour to the horses; because, from his want of skill, the swing-plough would be continually subject to sudden deviations, requiring him to use his strength to counteract them; and each exertion of the ploughman adds to the labour of the horses.

Without entering into any comparison of ploughs differently constructed, it is evident that the shape of the plough must vary with the nature of the soil which it is to turn up. A light soil must be shovelled up; a mellow one may be turned over with any kind of mould-board; a very stiff tenacious soil which adheres to any surface pressed against it, will be more easily turned over by a few points of contact which do not allow of adhesion. Hence the point and turn-furrow have been made of all imaginable shapes, and while one man contends for a very concave form, another will admit of nothing which is not very convex. That plough will no doubt have the least draught which is best suited to the soil which it has to move. The lighter the plough is, consistently with sufficient strength, the less draught it requires, all other circumstances remaining the same. Lightness and strength combined are consequently great advantages, and if a very light plough does its work as well as a heavier, there can be no doubt that it is preferable. Durability is nothing compared with the saving of one horse in three: it is cheaper to have a new plough every year than to keep an additional horse all the year. If a wooden plough is found to be more easily moved than an iron one, there can be no doubt which should be preferred.

The Flemish plough is made of wood, and is very light; the share and coulter only are of iron, besides a thin sheet of iron over the mould-board, which is shaped as if it had been rolled obliquely over a cylinder, a shape well adapted to sandy soils. In ploughing land which is more or less mellow and crumbling, the great object is to bring to the surface that portion which has lain buried, and has not served to nourish the preceding crop, and to bury that which has produced vegetation, and in which the roots of various weeds have established themselves. When manure is to be covered with a certain depth of earth, a more complete subversion is required, in order that no part of it may remain uncovered. When the land is in a compact state, from the roots which pervade it, and it is only ploughed once to prepare it for receiving the seed, much greater nicety is required to lay the slices at a certain angle so as to leave regular lines or depressions in which the seed may fall and be readily covered by the harrows which follow. In this case the angle of 45° is found to be the most convenient at which the furrow-slices may be laid against one another. The field will then have the appearance of being laid in small ridges as in the annexed figure, all towards the same side if ploughed with a turn-wrest plough, or towards a middle line if a plough with a fixed turn-furrow has been used. To produce this regularity, the end of the turn-furrow is made to press on the slice turned over. And if the mould-board be convex, as it is in most Scotch ploughs, and in those made by Hornsby of Grantham, this pressure is applied just at the right place to close the junction of the several slices.

Fig. 10.



When the seed is to be dibbled on the sward, which is reversed by a single ploughing, it is necessary that the sod should be completely turned over and laid flat. To do this, and at the same time to bury all the grass, requires the furrows to be very equal and parallel; so that when a roller has gone over the land, it is perfectly flat, without any interstices between the slices which are turned over. It requires a good ploughman to do this perfectly.

When clover-lea or old grass is ploughed up, it is difficult to bury all the grass which grows on the edge of the slice; and if it remains exposed, it will grow and increase to the detriment of the corn. To prevent this, a wing is sometimes added to the side of the coulter, a few inches from the point, or an additional skim-coulter is made to precede the ordinary coulter of the plough. It cuts a small horizontal slice off the surface before the sod is turned over, and this falls into the bottom of the furrow and is buried there. The coulter with such a wing is called a skim-coulter, because it, as it were, skims the surface. This instrument may require an additional horse to be put to the plough in tenacious soils, but this cannot be avoided. There is no doubt that no more horses should be put to a plough than can do the work; but whatever be the number required, the work must be done well. There is no saving in doing the work imperfectly. The discussions about the number of horses which should draw a plough might easily be settled, if the nature of the soil were sufficiently taken into consideration. The shape of the plough may make some difference, but the tenacity of the soil makes a much greater.

Very little attention was formerly paid to the straightness of the furrows. It was natural to follow the shape of the boundary of the field, which was seldom straight; and this practice increased gradually till no straight furrow was to be seen; and there was a prejudice, if not a superstition, in favour of crooked ridges. Those who defended them with the least vehemence, asserted that if crooked furrows were not better than the straight, the difference was unimportant; but no curves can be laid so perfectly parallel as two straight lines. Every deviation from parallelism causes a defect in the contact of the slices, and a loss of force by the obliquity of the draught. A superficial observer would not perceive this, but minute examination proves it. Hence equal and straight furrows are a sign of good ploughing.

When the land lies on a dry subsoil, and no more moisture remains in it, after continued rains, than is useful to promote vegetation, it may be ploughed quite flat. This may be done by a plough with a moveable turn-furrow, or by ploughing in very great widths. The best way is to draw a furrow the whole length of the field in the middle, and plough towards this from both sides. If the field is wide, it is most convenient to plough it into several broad stitches, each a certain number of perches in breadth. A perch (16½ feet) is a very common width for a "stitch," and convenient to guide the sower or the drilling-machine.

On wet undrained soils it is necessary to lay the land in a rounded form, in order to let the superfluous water run off into furrows, from which it is conducted by proper channels into the ditches. In this case half a perch is a common width for each stitch, or land, as it is sometimes called. It requires some practice to lay up a land in a rounded form from a flat surface. After cross-ploughing and harrowing, the first furrow is drawn wide and shallow, and the earth is thrown upon the surface to the right: when the plough returns, it takes another furrow about nine or ten inches from the first, laying the earth or furrow-slice somewhat obliquely over the first. At the next turn another slice is laid, meeting the last at an angle, the first slice being quite covered by the two last. This now forms the crown of the ridge; and the succeeding slices are laid obliquely, leaning to the right and left till the required width is obtained. Another land is now begun at the distance of a quarter of a perch from the last furrow, and laid exactly in the same manner. When the two lands meet, the intervening furrow, which had been purposely left shallower, is deepened; and there is a furrow between every two lands, the bottom of which is considerably below the bottom of the other furrows. When this field is ploughed again after harvest, the work is reversed; the furrow between the lands is filled with the first slice, and another is placed over this, which now becomes the crown of the land to be formed: this is called ploughing crown and furrow. When the lands are ploughed towards the crown, it is called gathering. By gathering several times in succession, the soil is much raised at the crown at the expense of the sides. This was the old practice, when lands were laid very wide and very high; in common fields, the land or stitch was often the whole width of the possession, from which came the name of land. In Scotland they are called riggs.

Fig. 11.

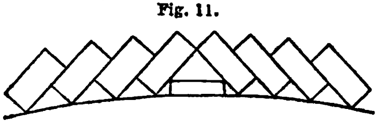
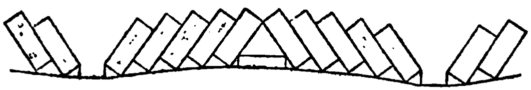


Fig. 12.



One of the most useful operations in ploughing land is to cross the former furrows, by which means the whole soil is much more completely stirred; and if any part has been left solid without being moved by the plough-share, which is called a balk, it is now necessarily moved. The leaving of balks is a great fault, and is owing to the sole of the plough being narrower than the furrow-slice, and the wing of the point too short, or to the ploughman not holding his plough upright. The share should cut the ground to the whole width of the furrow, that no roots of thistles, docks, or other large weeds may escape and grow up again. The Roman authors recommended the use of a sharp rod or stake inserted horizontally into the ground, to discover if there were any balks, which, with their ploughs, must have been often left, if the ploughman was not very careful to make close and small furrows. Many ploughmen hold the plough in an oblique position; the bottom of the furrow is consequently not level, and the soil is not stirred equally. This is a great fault, especially in wet ground; for the furrows thus become channels in which the water remains, not being able to run over the inequalities of the bottom. It is of no use to lay the surface convex, if the solid earth below lies in hollows or gutters. The water naturally sinks down into the newly-ploughed land, and if it be undrained it sinks only till it meets the solid bottom which the plough has gone over; if it can run over this into the deeper furrows between the stitches, it evaporates or runs off, and the land is left dry, and so consolidated as to let the water run along the surface without sinking to any depth; but if the bottom is uneven, it remains in the hollows, and stagnates there, to the great injury of the growing crops.

There are various modes of ploughing land when it is intended to pulverise and expose it to the sun in summer, or the frost in winter, to purify and fertilise it. To expose as great a surface as possible, the whole field is laid in high and narrow ridges, bringing to the surface all the fertile portion of the soil, and often also a portion of the subsoil so as to deepen the productive portion and give more room for the roots to spread in. The simplest method of increasing the surface exposed, when the land is first broken up from pasture, or after having been some years in grass, and is in a foul state, is called ribbing, or "raftering." The plough turns up a slice, which it lays over flat on the adjoining surface. It does not cover this with the next slice, as if it were beginning the crown of a stitch, but it takes another slice at some distance, and then one parallel to the first, likewise laid flat on the solid part. When the whole field has been so ploughed, the surface consists altogether of ridges and furrows; but only half the surface has been ploughed. No grass appears, if it has been well done, the unploughed strips being covered by the slices raised by the side of them, the two surfaces with grass on them cover each other. It is left in this state till the grass is rotten, and when the sod is broken to pieces by heavy drag-harrows, the land can be cross-ploughed and cleaned or fallowed in dry weather.

There is another mode of ridging, when the land has had one or two ploughings, in order to expose it to the frost in winter, and to mellow it. The operation is somewhat similar to ribbing, but after the first slice is turned over, another is added, as deep as the plough can be made to go, so as not to bring up the subsoil; by this means the whole surface is laid in high ridges and deep furrows; and when this ploughing is reversed, in spring, the soil which has been exposed to the frost and wind is mixed with the rest, and tends greatly to mellow it. This is an excellent preparation for turnips, if the land has been well cleaned. The manure, being distributed in the deep furrows, is covered by the plough right and left, or at one operation by a plough with a turn-furrow on each side, which divides the ridge and lays half of it in each contiguous furrow. This plough is usually called a double mould-board plough, and is extremely useful in many operations of husbandry.

In order to save hands and expedite the tillage of the land, ploughs have been contrived which make two or more furrows at once. When they are well constructed, they are very useful in light soils. If it is not required to go deep, and two horses can draw a double plough, there is a decided saving of power; but if it requires four horses, nothing is gained. The double ploughs are therefore not much in use. But there are instruments which cultivate the earth, stirring and pulverising it much more speedily than the plough. Some of these will stir the ground to the depth of seven or eight inches, going over a width of five or six feet at once. Such an instrument is preferable to the plough, after the ground has already had a certain degree of stirring, and is become mellow and crumbling; but to break up pasture or clover-lea, there is nothing so efficacious as the plough, which cuts regular slices and lays them over, so that all the grass shall rot, and the roots, being exposed to the air, shall decay, and thus furnish food for other crops.

The instruments which have been invented to save the time and labour required by repeated ploughings are very numerous. Some of the most useful have been noticed before. [Arable Land.] New ones are daily invented, and some are supported by wheels, which render them both lighter and more convenient. They are easily raised out of the ground, when not intended to work, and the depth to which they are let down is more easily regulated.

Deep ploughing is generally acknowledged to accord with the best husbandry, where the subsoil is dry naturally, or has been artificially drained; but some inconvenience may arise from bringing a barren subsoil to the surface, in trench-ploughing by two ploughs following each other in the same furrow. It has therefore been suggested to take off the turn-furrow from the plough which follows the first, so as to stir the subsoil without bringing it to the surface. [Arable Land.] This idea has been improved upon by constructing a subsoil-plough of great strength, which will go very deep into the ground and stir the subsoil a foot or more below the bottom of the usual furrow. Mr. Smith of Deanstone has invented one made entirely of iron, and Sir E. Stracey has constructed another with a small wheel in front very strongly put together, although the beam is of wood. Mr. Read, of Regent Street, London, has since manufactured another wholly of iron; and, in its turn, this has been greatly improved by the Marquess of Tweeddale, and is made by Mr. Slight of Edinburgh. This plough requires four horses in the most favourable soils, and six in tenacious clays, to keep up with the common plough, which always should precede it. Sometimes however the subsoil-plough may be used alone, where the surface is already mellow and crumbling.

Many different ploughs have been invented for the purpose of saving labour in draining land. As they all cut out a slice from the bottom of a furrow and raise it up to the surface of the ground, they are of little use in crumbling soils, and in the most tenacious require the assistance of much manual labour to complete the work. They act on the principle of the carpenter's tool by which a groove is formed in the edge of planks or deals, when they are intended to be joined closely as in a floor. This instrument is also called a plough; but the uniform tenacity of the wood allows a narrow chisel to cut an even regular groove. In the draining-plough the two sides of the drain are to be cut obliquely downwards and the bottom scooped out evenly. The plough requires to be often adjusted, and the deep furrows to be kept cleared from loose earth by means of spades and scoops. In this way, drains may be made from 15 to 18 inches deep, in which loose stones or tiles may be laid to form a channel for the water. The expense is much less than when the drains are made with the spade.

When grass-land lies low and wet on a very tenacious subsoil, a plough is sometimes used which consists of a cylinder of iron pointed at one end, and connected with a strong beam by a thick plate of iron which is sharp on the side nearest the point of the cylinder, and acts as a coulter. This instrument is forcibly drawn horizontally through the stiff subsoil at a depth of 18 inches to 3 or 4 feet, so as to leave a round channel like a pipe where the cylinder has passed. This has been called a mole-plough, the passage made by it under ground resembling the workings of a mole. It is most effectively drawn by steam power, but though easy and expeditious, it is only as a means of temporarily draining land that it can be approved.

Various ploughs have been constructed with the intention of diminishing the draught, or improving the form of the turn-furrow; but it may suffice to name as the most distinguished manufacturers of the present day—Messrs. Ransome of Ipswich; Messrs. Howard of Bedford, and Messrs. Hornsby of Grantham. In the application of steam to the impulsion of the plough, the effect sought to be produced is the same, the difference is in the power, and various patents have been obtained for steam-ploughs.

PLOUGH-MONDAY, the Monday next after Twelfth Day, fixed upon by our forefathers as the period when the labours of the plough and other rustic toils begin. In Derbyshire, and in some of the northern counties, the young men formerly used to yoke themselves and draw a plough about with music on this day; one or two persons, disguised in antic dresses, like jack-puddings, accompanying them, and going from door to door, soliciting plough-money to provide drink. In some places it was a custom, if the ploughman, after that day's work, came with his whip to the kitchen hatch, and cried "Cock in the pot," before the maid could cry "Cock on the dunghill," he gained a cock for Shrove-Tuesday. Tusser, in his 'Five Hundred Points of Husbandry,' mentions Plough-Monday among the ploughman's feast-days.

(Brand's *Popular Antiq.*, edit. by Sir H. Ellis, vol. i.; Brady's *Clavis Calendaria*, vol. i.)

PLUM. The *Prunus domestica* is generally considered as the species which has given rise to the numerous varieties of this fruit; but both *Prunus insititia* and *P. spinosa* have most probably contributed. These species are indigenous to a great portion of the northern hemisphere, Britain included. Their range may be stated to extend from Norway to Barbary, and from Portugal to Cashmere, and even Nepaul. Damascus was formerly celebrated for this fruit: branches of the plum are represented on Damascus medals; and many of the varieties now in cultivation still retain the name of this place, or it is employed as a distinguishing prefix to a number of subvarieties; thus the French enumerate upwards of twenty varieties of *Damas.* In this country the name of *Damascene* was given to those varieties which may be supposed to have been brought from Damascus, or to others similar; but the corruption of this to *Damson* has been long established. Whatever region may be the origin of them, it is certainly to France that we are indebted more immediately for the greater part of the varieties now actually cultivated.

In the 'Catalogue of Fruits,' published by the Horticultural Society, 274 varieties are named; but the mussel, orleans, and damsons are those best fitted for orchard culture in England, among the purple fruits; and the green-gage, especially in the southern parts, and the bullace, a coarse but useful variety, everywhere, among the pale fruits.

The cultivation of the plum is not difficult. The tree is hardier than the cherry-tree; but the blossoms are equally tender. The trees succeed in any free soil, not too dry, but by no means stiff or clayey. Their roots extend horizontally, and are apt to throw up suckers, which must be destroyed on their first appearance, otherwise they rob the tree, and form protuberances on the roots. Too much manure will actually kill the trees; and at all times a medium state of vigour should be aimed at. Excessive luxuriance is the forerunner of gummy exudations; and, on the other hand, if the tree be stunted and the vessels contracted by drought or other causes, whereby the sap is obstructed, gum is in that case also induced. Pruning should be applied to the plum in the same manner as to the peach; and in the management of standards care should be taken to destroy useless limbs on their first appearance, instead of waiting till the shoots to be removed become large branches. In training the plum the new wood should be cut away in winter, except those at the end of branches, and these should be cut back to half their length. The varieties are propagated both by budding and grafting; and for the latter, as the buds push early, the cuttings should be taken off not later than February. The wood-buds are easily distinguishable from the flower-buds by being more pointed.

PLUMBAGO. [Graphite.]

PLUMBATES. [Lead.]

PLUMBETHYL. [Organo-Metallic Bodies.]

PLUMBITES. [Lead.]

PLUMBLINE. When a heavy body suspended by a flexible string is at rest, the line passing through the point of suspension and the centre of gravity of the weight is in the direction in which gravity acts. The *horizon* is a plane perpendicular to this line, and the *zenith* is that point of the heavens marked out by the continuation of the line upwards. If the string be *perfectly* flexible, it will coincide with the theoretical line above described.

The application of the plumbline to the arts does not require any explanation here. Nor is it necessary to describe it in connection with astronomical instruments, as in most cases it has been superseded by the spirit level, or observation by reflexion.

PLUTO (Πλούτων), more frequently called by the Greeks Hades (῞Αιδης), and by the Romans *Orcus* and *Dis*, was the son of Kronos and Rhea, and the brother of Zeus and Poseidon. He was the deity that presided over the region where the departed souls of men were placed: the Zeus of the infernal regions. Hades, which is also written without an aspirate (Ades), is a word of uncertain etymology. Pluto is supposed to be connected with the Greek word signifying wealth (πλοῦτος), since the precious metals are found beneath the earth's surface, below which the abode of Hades was generally placed, and he alone was the possessor and the giver of them. The Latin Dis has the same meaning. Orcus is probably connected with the words εἴργω and *arceo*, and may signify "bound or restrained."

Pluto is represented by the ancient writers as a gloomy deity, inexorable to the prayers of mortals, and hated by the human race above all the gods. ('Il.,' ix. 159.) Whilst in his own kingdom he was unaware of what passed on earth, or in Olympus; but he sometimes ascended to Olympus. His wife was Persephone, called by the Romans Proserpina, whom he carried off whilst she was gathering flowers. [Persephone.]

In the 'Iliad' (ix. 569; xx. 61; xxiii. 100), and in the 'Theogony' of Hesiod (455, 767), the abode of Hades is said, as has been already stated, to be beneath the earth; but in the 'Odyssey' it is placed in the regions of darkness beyond the stream of ocean. ('Od.,' x. 508; xii. 81.)

The temples and statues of Pluto appear to have been very few. Pausanias relates (i. 28, § 6), that there was a statue of Pluto in the temple of the Eumenides, on the Areiopagus of Athens; and the same writer also informs us (v. 20, § 1), that there was a statue of this god in the temple at Olympia. There were also temples sacred to Pluto in Elis, Pylos, and other parts of Greece. Black sheep, a male and a female, were the sacrifices offered to Pluto and Persephone; and the person offering them was obliged to avert his face.

Few representations of Pluto by Greek artists have come down to us. In the statues and busts which are known, he resembles his brothers Zeus and Poseidon; but the countenance has a gloomier cast, the hair is lower on the forehead, and the drapery heavier. On vases, urns, and sarcophagi, he is more frequently represented carrying off Persephone, or enthróned with Persephone seated beside him.

In later writers, the word Hades also signifies the abode of the dead, as well as the deity who presided over it.

PLUTUS (Πλοῦτος), the personification and the giver of wealth, is said by Hesiod ('Theog.,' 969) to have been the son of Demeter and the hero Iasius. He is said to have been blinded by Zeus, in order that he might distribute his favours indifferently to the evil as well as to the good. (Aristoph., 'Plutus,' 90.) Plutus appears as an actor in the comedy of Aristophanes named after him; but we have no particulars respecting his worship. In the temple of Fortune at Thebes, Plutus was represented as a child in the arms of Fortune (Paus., ix. 16, § 1), and at Thespeia in Bœotia there was a statue of Plutus placed by the side of one of Athena Ergane. (Paus., ix. 26, § 5.) Pausanias also mentions a statue of Plutus in the arms of Peace, which Cephisodotus made for the Athenians. The attribute of Plutus was a cornucopeia.

PLUVIOMETER. [RAIN-GAUGE.]

PNEUMA'TICI (*οἱ πνευματικοί*), a medical sect founded by Athenæus about the middle or end of the 1st century A.D. [ATHENÆUS in BIOG. DIV.] Their principal doctrines have been noticed in the life of their founder. The sect appears to have existed but a short time, namely, from the reign of Vespasian to Antoninus Pius, and never to have enjoyed any great celebrity. For further information concerning it the reader may consult Wigan, 'Præfat. in Aret.;' Ackermann, 'De Aretæo;' and especially Osterhausen, 'Dissert. Inaugur. de Sectæ Pneumaticorum Medicorum Historia.'

PNEUMATICS. This name is given to that part of physics in which are contemplated the mechanical properties of elastic fluids, principally atmospheric air. The word is derived from *πνεῦμα*, 'breath or spirit,' and pneumatology is a term which was once applied to the division of science now called metaphysics.

The mechanical properties of air appear to have been, to a certain extent, known to the ancients. Aristotle must have been aware of its materiality, and of its tendency to descend towards the earth, like other heavy bodies, for he observes that if a bladder be filled with air, it weighs more than when empty: the observation proves at least that he had the idea, but it may be doubted whether or not he ever made the experiment, since it is not probable that he had the means of weighing the full bladder in vacuo, or that he could keep it distended when the air was extracted from it. The invention of a species of forcing-pump for raising water, and of instruments for producing sounds by the passage of air through orifices in tubes, both of which are ascribed by Vitruvius (lib. ix., x.) to Ctesibius, who lived about 130 years B.C., are proofs that the elastic force of compressed air must have been then apprehended and made subservient to purposes connected with practical utility.

The ascent of water in pumps, on raising the piston, must have been for ages observed, without a suspicion being entertained of the cause; and the principle that the existence of a vacuum was impossible, was held to afford a sufficient explanation of the phenomenon. Even Galileo, when made aware, by the formation of a vacuum between the piston and the water when the latter was at its greatest height in a pump, that the principle was unfounded, had recourse to another which was equally remote from the truth; for he is said to have ascribed the ascent of the water to the attraction of the piston, and to have accounted for the height of the column never exceeding a certain quantity (about 34 feet) by a supposed equilibrium between the weight of the column and the attractive power of the piston. The steps by which Torricelli arrived at the discovery of the true cause of the phenomenon, and at the same time, the determination of the pressure of the atmosphere by the weight of the column of mercury supported in a tube closed at the upper extremity, are noticed under BAROMETER.

Soon after the commencement of the seventeenth century, the idea of ascertaining with precision the state of bodies with respect to temperature by the expansion of fluids when acted on by heat, is said to have occurred to the members of the Academy del Cimento, at Florence; and this gave rise to the invention of an instrument of great importance, as well for many occasions of ordinary life, as for the purposes of pneumatical science. [THERMOMETER.]

The desire of perfecting the theory for determining the heights of mountains by the barometer, led to numerous researches in order to ascertain the relations between the condensation of air and the forces compressing it, and also to discover the effects produced by variations of temperature. About the year 1650, Boyle in England, and about 1676, Mariotte in France determined from experiments, that when the temperature was constant, the density of air was proportional to the compressing force; but it was not till a century afterwards that De Luc determined the expansion consequent upon given increments of temperature.

In the beginning of the eighteenth century, steam began to be employed as a moving power for pumps and other machinery. The law of the resistance of the air to bodies moving in it was discovered by Sir Isaac Newton; but the intensity of this resistance against military projectiles was first determined, for the inferior velocities, by Robins, in 1740; and Dr. Hutton subsequently obtained a formula which, with perhaps sufficient correctness, may be employed with any velocity whatever. [GUNNERY.] The expansion of fired gunpowder has been determined from the researches of Robins, Euler, and Hutton; and that of steam has been investigated by Dalton in England, and by Prony, Arago, and other distinguished physicists in France. [STEAM.]

If a fluid be conceived to be perfectly elastic, it is evident that it can be made to occupy a given volume only by being confined within a close vessel, or by the pressure of a circumambient fluid. In the latter case it is easy to perceive that while the temperature of the elastic fluid remains the same, the spaces occupied by it will be diminished when the compressing force is increased, and increased when the latter is diminished; and that the density, or degree of closeness of the particles, will vary directly with the change of volume. Now the compressing forces which are made to act on the surface of an elastic fluid are usually estimated in terms of the pressure exerted by a vertical column of the atmosphere, its base being equal to some unit of superficies, as one square inch or foot. Whatever be the constitution of such column, its weight or pressure is known, in a given state of the atmosphere, by direct experiment, and this is usually designated the pressure of one atmosphere: the same pressure is also frequently expressed by the height of the column of mercury which is supported in a barometer-tube by the counteracting weight of the atmospheric column.

A simple experiment suffices to show the relation between the density and elasticity of a fluid and the compressing force. Let mercury be poured into a bent tube open at one end and closed at the other; the sum of the weights of the column of mercury and of the atmosphere above it in the open tube, will reduce the air in the closed tube to a volume less than that which it previously occupied. Let, then, more mercury be added, and the volume of air will be still further reduced at every addition of mercury: and it will be found that the volumes of air vary inversely as the sums of the weights of the mercury and atmosphere. Therefore, since the density of an elastic fluid is inversely proportional to the space it occupies, it follows that the densities are directly proportional to the compressing weights; and since the weights of the mercury and atmosphere together, in the open tube, are balanced by the elastic force of the condensed air in the close tube, that elastic force is also directly proportional to the compressing force, that is, to the density. [AIR.] This is the law of Boyle and Mariotte, and though it cannot be said to be absolutely correct for very great pressures, it is sufficiently so for all practical purposes. (See the elaborate experiments of Magnus, 'Annales de Chimie et de Physique,' 3 serie, iv.; and of Regnault, iv. and v.)

The following table, extracted from the results of the experiments made by MM. Prony, Arago, and others, exhibits the volumes and elasticities of a given quantity of atmospheric air under different pressures, the temperature being nearly constant, and expressed by 14° of the centigrade thermometer (57·2° Fahr.), and, as far as it extends, it confirms the law above mentioned. The first of the columns expresses the pressure or elasticity in multiples of the weight of an atmospherical column; the second expresses the same by the height, in inches, of the column of mercury supported in a barometer tube; and the third column contains the corresponding volumes.

Atmospheres.	Inches, Eng.	Volumes.
1	30	1·0000
5	150	·1989
11·3	339	·0884
16·5	495	·0601
21·7	651	·0457
24	720	·0411
27	810	·0369

The law being admitted, it may be proved that the particles of an elastic fluid repel each other with a force which varies inversely as the distance between them. For let the volume of fluid be in the form of a cube, and let the compressing force act perpendicularly on one of its faces; then, if d represent the distance between any two adjacent particles of fluid, the number of particles in the surface pressed will vary as $\frac{1}{d^2}$. Now assume that the repulsive force (perpendicularly to that surface) between any two adjacent particles in the volume varies as d^n; then the whole repulsive force on that surface, and, consequently, the compressing force, will vary as d^{n-2}. If D represent the density of the fluid, d will vary as $\frac{1}{D^{\frac{1}{3}}}$, or $D^{-\frac{1}{3}}$; therefore, substituting $D^{-\frac{1}{3}}$ for d in the last expression, the whole repulsive force varies as $D^{-\frac{1}{3}(n-2)}$. But, agreeably to the law above mentioned, the compressing force varies as D; therefore the exponent $-\frac{1}{3}(n-2)$ must be equal to unity, and hence $n = -1$. It follows therefore that the repulsive force between any two adjacent particles varies as d^{-1}, or inversely as the distances of those particles from each other. Sir I. Newton however observes (lib. ii., prop. 23, schol.) that this law holds good only when the repulsive power of any particle does not extend much beyond those which are nearest to it.

If P and P′ represent the pressures exercised upon a square unit of the superfices bounding an elastic fluid, and the volumes of the fluid under those pressures V and V′; also if the densities be D and D′ respectively, we shall have

$$P : P' :: V' : V, \text{ or } P.V = P'.V',$$
$$\text{and } P : P' :: D : D', \text{ or } P.D' = P'.D;$$

whence, by equality of ratios,

$$V : V' :: D' : D, \text{ or } D.V = D'.V'.$$

Considerable difficulty is found in determining the specific gravities of gases with precision, and different experimenters have obtained results which do not exactly agree. The value generally adopted when the height of the column of mercury in the barometer is 30 inches, and the temperature is 60° Fahr., is 31·074 grains as the weight of 100 cubic inches of dry air. Other physicists have found it as low as 31·0117 and 30·935 grains; but the former is probably most correct, as it agrees with the density of air as deduced from that of a mixture of oxygen and nitrogen in the proper proportions to form air. Air is therefore $\frac{1}{816}$ of the density of water. The experiments of Dalton have led to the conclusion that the weight of a cubic foot of steam when at the temperature of 212° Fahr., the height of the barometrical column being 30 inches, is 253 grains troy; by others it has been found to be 254·7 grains; and it appears that within considerable limits the expansion of the volume of any gas is proportional to the increments of temperature, measured by the degrees of the thermometer. The absolute value of the expansion is not precisely known; that of air is stated to be equal to about $\frac{1}{491}$, and that of steam about $\frac{1}{450}$ of the volume, for one degree of Fahrenheit's thermometer. [AIR.]

The following table, from the observations of MM. Dulong and Petit, exhibits the volumes assumed by a given quantity of air at different temperatures between the boiling-point and near the freezing-point of mercury:—

Temperatures.	Volumes.
—33°	0·8650
32	1·0000
212	1·3750
302	1·5576
392	1·7389
482	1·9189
572	2·0976
680	2·3125

It has been mentioned that the rate of expansion of all gases is equal and uniform at all degrees of temperature and pressure, and that the amount of the expansion is $\frac{1}{491}$ of the bulk occupied at 32° Fahr., for every degree of temperature, so that a quantity of any gas, which, at 32° Fahr., measured 491 parts, will, at 33° Fahr., measure 492 parts, and so on. If, then, it were required to find the volume which 9·2 cubic inches of any gas, measured at 70° Fahr., would have, when reduced to 60°: since 70 — 32 = 38, 491 parts of the gas at 32°, would become 529 parts at 70°. Again, 60 — 32 = 28, so that the gas at 60° would, similarly, occupy 519 parts. Hence, we have the proportion, 529 : 519 : : 9·2 : x (= 9·026 cubic inches).

From experiments it has been concluded that, while steam is in contact with the water from which it is formed, its expansive force increases in a geometrical progression, so long as its temperature is at the same time increased in an arithmetical progression, but the relation between the elastic force of this gas and its temperature, in that state, is as yet far from being certainly known. Under the word ELASTICITY is given a table of the elastic forces of steam at temperatures between the freezing and boiling states of water; and the following table, extracted from those which have been formed from the results of the experiments of Mr. Dalton, Dr. Ure, and the French physicists, may also be useful as a means of affording a near estimate of the force at high temperatures. The first column contains the temperature of the water and steam in degrees of Fahrenheit's thermometer; the second is the measure of the expansive force by the number of inches in the height of the column of mercury which on a given superficies would counterbalance it; and the third, the like measure expressed by multiples of the weight of the atmospheric column when the air is in its ordinary state:—

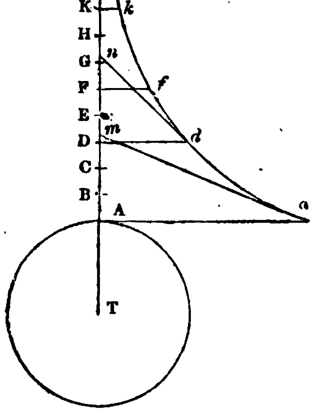
Temperature.	Inches, English.	Atmospheres.
212°	30	1
220	35·54	1·18
240	51·7	1·72
260	72·3	2·41
280	101·9	3.06
300	139·7	4·66
312	165·5	5·52
340	231·	7·7
357	296·70	9·893
389	435·9	14·53
408	541·5	18·05
419	613·2	20·44
435	719·8	23·994

When steam is not in contact with the water from whence it is formed, and when it is subject to a constant pressure under which it may expand in every direction (as when it is formed in the atmosphere), an increase of temperature will not produce an increase of density, but merely of its elastic power. Again, if steam be in contact with its water, and the temperature remain constant, its density, whether in air or *in vacuo*, will remain constant, and its volume only will vary. But if, in this case, its volume be kept constant, and the temperature be increased, its density will rapidly increase, as before, until the whole of the liquid is evaporated, and then the expansion of the steam will follow the usual laws of permanent gases. The only difference in these experiments between using a vessel containing air, and one having a vacuum inside is, that in the former case the results do not *at once* appear, until time has been allowed for diffusion.

It has been found that the volume of gas disengaged from gunpowder is equal to about 300 times the volume of the powder itself; and that its expansive force, when increased by the heat which is generated at the time of the explosion, is about 1500 times as great as the pressure of the atmosphere in its ordinary state. It must consequently exert a pressure against a cannon-ball, and the interior of the chamber of the gun, equal to about 15,000 pounds upon every square inch of the surface upon which it acts.

The fact that the density of air varies with the compressing force is sufficient to show that the atmosphere about the earth cannot be of uniform density; and it is also evident that the density must diminish from the surface of the earth upwards, according to some law depending on the height of any point above the earth, or rather upon the weight of the mass of air above that point. It might, at first, be supposed that the atmosphere would extend upwards to a height at which the centrifugal force of the particles of air (by the diurnal revolution) is equal to the force of gravitation; and it is shown by Poisson ('Traité de Mécanique,' tom. ii., 619) that, conformably to this principle, the height of the atmosphere at the equator should be equal to about five times the semi-diameter of the earth. But it is probable that, long before this height is attained, the air loses its elasticity by the cold in the upper regions, or that its expansion is destroyed by the pressure of the ethereal fluid which is diffused through infinite space. By the duration of twilight it is inferred that the atmosphere is capable of reflecting the sun's rays at the height of about 45 miles above the earth, and it is probable that some light is reflected from a still more elevated region.

In order to determine the law by which the density of the atmosphere diminishes at increasing distances from the earth's surface, on the supposition that the action of gravity and the temperature of the air are constant, let T be the centre of the earth, and let A Z be the height of a very slender column of air extending vertically upwards to the top of the atmosphere. Also let the atmosphere be divided into an infinite number of concentric strata of equal thicknesses, which latter are represented by A B, B C, C D, &c.; and, as these thicknesses are small, let the density of the air in each stratum be supposed uniform and equal to that which is due to the weight of all the strata above it.



Let d_1, d_2, d_3, &c., represent the densities of the several strata whose heights are AB, BC, CD, &c.; these terms may also represent the weights of the slender columns AB, BC, CD, &c.; consequently the weights of the columns AB, AC, AD, &c., may be respectively represented by d_1, d_1+d_2, $d_1+d_2+d_3$, &c. Then, the density in each stratum being proportional to the weight, or sum of the densities, of all above it, we have

$$d_1 : d_2+d_3+d_4+d_5+\&c. :: d_2 : d_3+d_4+d_5+\&c. \quad \text{(I)}$$

In like manner

$$d_2 : d_3+d_4+d_5+d_6+\&c. :: d_3 : d_4+d_5+d_6+\&c. \quad \text{(II)}$$

or, by composition,

$$d_2 : d_2+d_3+d_4+d_5+\&c. :: d_3 : d_3+d_4+d_5+\&c. \quad \text{(III)}$$

In like manner

$$d_3 : d_3+d_4+d_5+\&c. :: d_4 : d_4+d_5+d_6+\&c. \quad \text{(IV.)}$$

Then, from (I) and (III), by equality of ratios, we have

$$d_1 : d_2 :: d_2 : d_3.$$

And, from (II) and (IV), by equality of ratios, we have

$$d_2 : d_3 :: d_3 : d_4;$$

and so on.

Thus d_1, d_2, d_3, d_4, &c., are in a geometrical progression decreasing.

Now AB, AC, AD, &c., form an arithmetical progression increasing; or, reckoning both the heights and the densities from any point, as K, downwards, the former (that is, KH, KG, KF, &c.) form an arithmetical progression, and the densities in KH, HG, GF, &c., form a geometrical progression, both increasing. But a series of numbers in an arithmetical progression being made to correspond to a series in geometrical progression, the former numbers are logarithms of the latter; and thus the distances KH, KG, KF, &c., may be considered as representing the logarithms of the densities in the strata KH, HG, GF, &c., respectively.

Imagine any point K to be the origin of the abscissæ (represented by x) on the vertical line ZA; and imagine any horizontal ordinates Kk, Ff, &c. (represented by y) to be drawn; then, if KF, KD, &c., be proportional to the logarithms of Ff, Dd, &c., the line $adfk$, &c., is called the logarithmic curve, and its equation is log. $y=x$ log. a, or $y=a^x$ [LOGARITHMIC CURVE], where a is some constant which is called the base of the system of logarithms appertaining to the particular curve.

Now it has been demonstrated by mathematicians, that if tangents am, dn, &c., be drawn from any points in the curve, the subtangents Am, mn, &c., will be equal to one another; and that the area comprehended between the infinite branch az of the curve, its asymptote AZ, and any ordinate Aa, Dd, &c., is equal to the product of the constant subtangent, or modulus of the curve, and that ordinate: hence the area between Aa and the infinitely remote summit Z is equal to Aa × Am. Also, by the nature of logarithms, the logarithms of the same natural number in different systems of logarithms bear to one another the same proportion as the moduli of those systems. We have therefore only to find the value of the subtangent Am, or modulus, for what may be called the atmospherical logarithms. For this purpose, let h denote the height of a homogeneous atmosphere whose density is equal to that of the real atmosphere at the surface of the earth, which density is represented by the line Aa in the above diagram; then h × Aa will represent the weight of such homogeneous atmosphere, or its pressure on the point A. But the area between ZA, Aa, and the curve being supposed to be made up of the infinite number of ordinates Aa, Dd, Ff, &c., which, severally, represent the densities of the air at the points A, D, F, &c., in the infinitely high column AZ of atmospherical air; that area, namely, Aa × Am, may represent the weight of such column, or the pressure of the real atmosphere on the point A; this being made equal to the former pressure, it is evident that we shall have A$m=h$. Thus the height of a homogeneous atmosphere exercising at A the same pressure as the real atmosphere, will be the subtangent, or modulus, of the atmospheric logarithms. The value of h is determined by a proportion in which the heights of the column of homogeneous air, and the column of mercury which holds it in equilibrio, are to one another inversely as the specific gravities of the two fluids. [HYDROSTATICS.] Now the specific gravities of air and mercury being, respectively, proportional to about 1·22 and 13568; and the height of the column of mercury in the barometer being 30 inches when the temperature is expressed by 55° Fahr., we get 27803 feet, for the value of h. Hence the height of a homogeneous atmosphere would be about 27803 feet, or a little more than 5 miles from the sea-level, while the mean density of the atmosphere (in its present state) is at about 3½ miles.

The mountain-barometer, as it is called, is usually provided with an adjusting screw, by which the surface of the mercury in the cistern may be made to coincide with the zero of the scale of inches by which the height of the column is expressed; but those of a more portable kind have not that adjusting screw, and then a correction must be made for the error of the scale. [BAROMETER.]

Water boils when the elastic power of the vapour formed from it is equal to the incumbent pressure; and consequently the temperature at which the boiling takes place in the open air will depend upon the weight of the atmospheric column above it. Therefore, since this weight becomes less as the station is more elevated, it is evident that water will boil at a lower temperature on a mountain than on the plain at its foot; and the Rev. Mr. Wollaston constructed an instrument called a thermometrical barometer, by which, on the principle just mentioned, the relative heights of stations can be found. A tube containing the mercury is provided with a graduated scale, and, when used, the bulb is placed in a vessel of water, which is made to boil by means of a spirit-lamp. An improved form of the apparatus is represented under BOILING OF LIQUIDS.

In order to determine the heights of stations merely by the knowledge of the temperature at which water boils, the formula $F = \left(\frac{t+75^\circ}{85}\right)^6$ given by Mr. Tredgold, might be employed. Here t is the temperature of the boiling water at the station, expressed in degrees of the centigrade thermometer; F is the measure of the elastic force of the steam at the temperature t under the pressure of the atmosphere, and is expressed by the corresponding height, in centimetres, of the column of mercury in a barometer.

The velocity with which air flows into a vacuum through an aperture in a vessel follows the same law as water or any other non-elastic fluid [HYDRODYNAMICS]; for though, in the former case, the quantity of air passing through the orifice in a given time varies with the density of that which successively comes to the orifice, yet the pressure by which the air is forced out varying in the same proportion, the velocity, by dynamics, remains constant.

Now, the velocity acquired by a falling body in vacuo is known to be $=\sqrt{2gx}$, if $g=32$ feet, and $x=$height fallen through. (DYNAMICS.) Hence, if $v=$velocity with which the air rushes through a small hole into a vacuum at the sea-level, $v=\sqrt{2gx}$, namely, $v=$the velocity of a particle of air supposed to have fallen from the height of a homogeneous atmosphere into the aforesaid hole. So that $v=\sqrt{2 \times 32 \times 27803}$, from above.

$$\therefore v = \text{about } 1339 \text{ feet per second.}$$

The law is the same, whether we consider the air to act only by its weight, or whether it be confined in a vessel and the efflux be produced by the elasticity. For, the air in the vessel being in the ordinary state of the atmosphere, the pressure against every point on the interior surface is equal to the pressure of the atmosphere by which, if not otherwise confined, it would be kept in its actual state; consequently it begins to flow from the orifice with the same velocity as if it had been impelled by the weight of the whole column of atmosphere above the orifice, that is, with the velocity due to the descent of a body from a height equal to that of a homogeneous atmosphere. After this moment, the density of the air in the vessel diminishing, its elasticity diminishes with it, and consequently the power of motion is diminished in the same ratio as the density. It may be added also that, since density of air increases with the pressure, an additional pressure on the fluid in a vessel will not increase the velocity of the efflux. But the law just mentioned only holds good when the vacuum is supposed to remain perfect on the exterior of the orifice: for, if the air be received in a vessel, it will expand in that vessel and re-act against the effluent air at the orifice, thus diminishing the velocity till the latter finally becomes equal to zero; and this will take place when the air has attained the same density in the two vessels.

If the effluent air be of a given density, but not the same as in the ordinary state of the atmosphere, the force by which it would be made to flow into a vacuum must be determined by the above equation $PD'=P'D$; where P is the pressure (or weight of the column) of the ordinary atmosphere, and D its density at the earth's surface; D′ is the given density and P′ is the required pressure or force by which that air would be impelled through the orifice. Now if air in the ordinary state be allowed to rush into a vessel containing air less dense than itself, and the velocity of efflux be required, the moving force will be the difference between that with which the ordinary air is driven through the orifice and that with which the rarer air would be so driven; that is, it may be represented by $P - P'$; then the velocities of efflux being as the square roots of the forces [HYDRODYNAMICS], if the velocity due to the force P is given, the required velocity at the commencement of the efflux may be found.

The determination of the velocity with which dry steam or any other elastic fluid rushes into a vacuum, or into a fluid of less density than itself, is made in the same manner as for air. Thus, knowing the temperature of steam, and consequently its elasticity, or the equivalent pressure, we can find the height of a homogeneous atmosphere which would produce the same pressure; and then the velocity with which the steam flows into a vacuum would be equal to that acquired by a body in falling down the height of such atmosphere. But if the steam is to flow into any elastic fluid of less density than itself, the height of the homogeneous atmosphere must correspond to the difference of the pressures arising from the different elasticities of the two fluids.

Finally, it has been lately found by some very accurate experiments recorded by Professor Potter, that, if we represent by v the theoretic velocity of efflux of air through a small orifice, and by v' the experimental velocity, then

$$v' = .65\ v, \text{ for orifices in a thin wall,}$$
$$= .93\ v, \text{ for cylindrical spouts,}$$
$$= .94\ v, \text{ for conical spouts, and those}$$

narrowing from the wall of the gasometer; so that there is, as for liquids, a true *vena contracta*, which reconciles theory with experiment, as in the case of Torricelli's theorem. [EFFUSION; HYDRODYNAMICS.]

PNEUMIC ACID. The lungs of most animals contain a peculiar acid, partly free, but chiefly in the form of a soda salt, to which this name has been given. Its composition is unknown and hence its existence as a distinct acid must be regarded as doubtful.

PNEUMONIA. [LUNGS, DISEASES OF.]

POACHING. [GAME LAWS.]

POETRY, in the usual and proper signification of the word, is applied to any composition in metre. It designates the outward form, not the style or the subject-matter treated. As, however, there are certain subjects, certain feelings and language, which belong to good poetry, a prose composition, in which these characteristics are visible, is often termed "poetical" or "poetry," just as a bad poem is called "prosaic." In both instances we speak thus when we wish to express praise or blame, as the case may be, and we use the words metaphorically. (See Whately's 'Rhetoric,' page 278.)

The art of poetry is an imitative art. Its object, in common with all such arts, is to give pleasure by imitation. So far music, painting, sculpture, and poetry agree. They differ in the means which each employs to effect the imitation. Music works by harmony and melody, painting by colour, sculpture by form, and poetry by words arranged in metre. In no case, however, is it the proper province of art to produce illusion, that is to say, the person whose feelings are to be affected always remains conscious that his emotion is not the result of anything really passing, but is merely analogous to that emotion which the reality would produce.

The imitative power of art thus consists in producing results resembling, but not identical with, those created by natural objects, or by human passion, character, and action. Hence the difference between a diorama and a picture, or between a waxwork figure and a statue; illusion is the aim of the one; imitation, properly so called, of the other. Hence, too, it is difficult to vindicate the mimicry of special sounds, such as hail or thunder, in music.

The metre in poetry answers a double purpose: in itself it affords pleasure by its rhythm, and acts as a powerful auxiliary to the sense which the mere words express; but, above all, it preserves the essence of art by operating as a constant barrier against any approach to reality. In this way the poet avows the fact that his work is a work of art, and he makes the reader or hearer aware of the relation in which he and the author stand to each other. The imitative power may work in safety when hedged off from real life by the fence of metrical form, and thus it is that Wordsworth lays down the "perception of similitude in dissimilitude" as one of the principles on which verse gives pleasure.

The next question is, in what mode does poetry imitate? Painting and sculpture copy outward forms themselves; poetry and music, being restricted to instruments of a different kind, aim at imitating the effect of those forms, that is to say, at producing the pleasurable emotion in the reader or the hearer, though in these cases they cannot imitate the means. On the other hand, the two former arts can only represent one moment of action or expression, and must tell their story by selecting that moment properly; music and poetry can supply a succession of images and sentiments all going to make up a whole. There is one advantage which poetry possesses over all its sister arts, viz., that of being able to assert: as it is the only art which employs words for its instruments, it is the only one which can enounce a proposition and command this element of the moral sublime.

Poetry, ποίησις, or "making," seems to be so called because good poetry creates or re-embodies the impressions which the poet has imbibed into his own mind by observation. This faculty of producing from such elements the impression of individual character, action, or scenery is the power which we generally term imagination. Without it, the attempt at imitation must necessarily fail. Wordsworth (Preface to 'Lyrical Ballads') says, "Poetry is the spontaneous overflow of powerful feelings; it takes its origin from emotion recollected in tranquillity. The emotion is contemplated until by a species of reaction the tranquillity gradually disappears, and an emotion kindred to that which was before the subject of contemplation is gradually produced, and does itself actually exist in the mind." This we take to be a description of the mode in which imagination works. The poet, by close and habitual observation, stores his mind with the circumstances which have given rise to or attended the production of emotion in himself. The result of this observation he works up so as to create in others an emotion kindred to that which he has himself experienced; kindred, but not identical, for, as Wordsworth truly remarks, the excitement must co-exist with an overbalance of pleasure. Now, many of the emotions which the poet excites are, when called forth by real events, peculiarly painful. It is his business so to combine them with pleasing associations, so to soften their disgusting features and render prominent their more attractive ones, and above all so to give unity to the whole, that, taken with the consciousness of their existing in a work of art, and not in reality, they become a source of exquisite delight. Such a work is reality, seen through the medium of the poet's mind, and clothed by him in a bodily form so as to retain its vividness, but lose its deformity.

It has been often observed that the language of savages is highly metaphorical, and what is commonly called poetical; that nations in their earlier stage show a peculiar fondness and aptitude for poetry. The truth is, that there exists in the mind of man a natural craving for individuality. We gain knowledge by generalising from individual objects, and we are always eager to re-embody our abstractions. Even in the most civilised state, there is a perpetual tendency in the mass of mankind towards "realism," while the consistent and familiar use of abstract terms and symbols implies long and severe discipline of the reasoning powers. These feelings are the groundwork of all allegory. If we reflect a moment, we know that "justice" means that disposition of mind which we see exhibited by individuals who are called "just," yet we speak of her as if she were a real existing being, and paint her with a pair of scales and a sword. Thus the appetite for the imitative arts is one deeply implanted in man; he cannot be satisfied unless character or action lie embodied to the eye by colour or form, or brought vividly before the mind by the description of the poet. Abstract terms are indistinct, and require metaphors or similes to give them substance and make them palpable to the apprehension. One of the most wonderful phenomena connected with the Greeks is, that while the genius of the people constantly tended, as Bishop Thirlwall says, to embody the spiritual and personify the indefinite, they excelled no less in the dry and abstract studies of philosophy. If Homer, if Æschylus and Sophocles, have never been rivalled in poetry, it was Aristotle on the other hand who analysed with the greatest precision the process of human reasoning, and left us in his 'Ethics' and his 'Politics' treatises which are still instructive in their respective departments.

We must now proceed to say something of the diction of poetry. Words are the instruments of the poet; they are the tools with which he works. We think that Mr. Wordsworth pushes his theory of simple language a little too far. We fully sympathise with his rejection of "those phrases and figures of speech which from father to son have long been regarded as the common inheritance of poets." Such conventional forms of expression at last become adverse to the very object of all poetry; instead of conveying any definite or substantial image, they degenerate into mere formulæ of the vaguest and most unsatisfactory kind. But, just as metre at once gives pleasure by its adaptation to the subject-matter, and forms a sort of framework in which the poet exhibits his composition to the reader, so may language, by its appropriateness and by its dissimilitude to the phraseology of common life, supply another twofold source of pleasure. There are ballads, and even larger compositions, in which the simple and homely diction suits the treatment of the subject and adds force and strength to the expression. But, who will say that in such a work as the 'Agamemnon' of Æschylus, where the whole drama is knit together by one pervading feeling of mysterious dignity, the language should not bear a proportion to the other qualities of the work?

"Let gorgeous tragedy
In sceptered pall come sweeping by:"

stately and ornate diction is a part of her trappings.

It remains to speak briefly of the different moulds into which a subject may be cast by a poet, and according to which we call a poem epic, dramatic, lyric, &c. There is great difficulty in this part of our subject. The ancients, indeed, applied such terms as "epos," or "elegeion," to the outward form only, but, in modern language, the matter of a poem, its length, or its mode of treatment, often decides the class to which it is commonly assigned. Moreover, there are many works of a mixed character which we cannot place in any recognised division. To what genus do Dante's 'Divina Commedia,' Wordsworth's 'Excursion,' and Spenser's 'Fairy Queen' respectively belong? Certain broad distinctions may, however, be laid down, though they be incapable of definite application in every instance.

1. A poem may be in the form of a narrative of events which the poet professes to recount; although he sometimes introduces his heroes as speaking in the first person, and uses the historical present tense for the sake of greater energy, still the events are supposed to be *past*. The subject-matter is external, that is to say, the writer does not merely pour forth his own feelings as excited by certain actions or circumstances, but describes the actions or circumstances themselves. Of this kind is all epic and narrative poetry.

2. A poet may develope the action to the reader or supposed spectator by imagining that the personages of the story show its progress and their own characters by what they themselves say and do, not by what the author narrates of them. Here the time is supposed to be present, and the subject-matter still more purely external. Dramatic poetry, with all its numerous subdivisions, is of this kind.

3. The author may principally aim at expressing the overflow of his own emotions and his own sentiments, instead of narrating what is past, or supposing something present to be acted before us. His object will then be to awaken an echo of similar feelings in the reader

or hearer, and thus *imitate* the action of those impulses which have previously excited such feelings in his own mind. Most short compositions intended to be sung belong to this class. If the tone of thought is enthusiastic and the metre irregular, we call the work an ode; if it express tender or mournful feelings in a more regular form, it is an elegy; the name of "sonnet" marks the outward form only. Perhaps no general word can be found so applicable to the greater part of those compositions, which are neither epic nor dramatic, as the term "lyrical," though it does not seem in any usual sense to include epigram, satire, or didactic poems.

The different classes of poetry are further treated of under the heads —Ballad, Drama, Epic Poetry, Lyric Poetry, Ode, &c.

POINDING, in the law of Scotland, is a process for enforcing payment of a debt, against the property of the debtor. It is divided into "personal poinding," and "poinding of the ground." The former is the method by which any ordinary creditor attaches the moveables of his debtor; the latter is peculiar to the holders of real rights over estates belonging to others—as to superiors entitled to feu duties or the holders of real securities entitled to payment of the interest—who can by this process attach the rents or other proceeds of the estate, and pay themselves. Personal poinding is the most usual form—it is of very frequent occurrence, and is a rapid and effective process, analogous to the "distress" of the law of England.

POINT, in Music. [Fugue.]

POINT. [Solid, Surface, Line, Point, Definition of.]

POINT OF CONTRARY FLEXURE. By this term is understood a point at which a curve changes its curvature with respect to any given external point, being concave on one side and convex on the other. [See the figure in Curve for instances.]

The mathematical test of a point of contrary flexure in a plane curve is as follows:—Let $y=\phi x$ be the equation of the curve, and let y'' be the second differential coefficient of y with respect to x. As long as y and y'' have the same sign, the curve presents its convexity to the axis of x; and when y and y'' have different signs, its concavity. When y'' changes sign, there is a point of contrary flexure, if y be then finite; and this, whether it passes through zero or infinity at the change. (Library of Useful Knowledge, 'Diff. Calc.,' pp. 369, 370.)

It is frequently stated in elementary works, that there is a point of contrary flexure when $y''=0$, and the converse. Both propositions are inaccurate: there is not necessarily such a point when $y''=0$, and there may be such a point when y'' is not nothing, but infinite.

For example, let $y=x^2-\dfrac{1}{x}$, which gives $y''=2-\dfrac{2}{x^3}$. As long as x is less than 1, y'' is negative, and so is y, whence the curve is convex to the axis of x. When $x=1$, both y and y'' vanish, and when x is greater than 1, y and y'' are both positive, so that the curve is still convex. But there is a change of sign in y'' when x passes through 1; and therefore there is a point of contrary flexure when $x=1$. It is to be remembered that though at a point of contrary flexure the curve changes curvature with respect to any line not passing through the point, it preserves its curvature with respect to every line which does pass through the point, being on both sides convex, or on both sides concave, to that line. In the present instance, the curve is always convex to the axis of x; consequently, where it has a point of contrary flexure, it cuts that axis.

At every point of contrary flexure, the Tangent passes through the curve, and has a contact of an order different from that which it usually has. The radius of curvature at a point of contrary flexure is always either nothing or infinite.

Some English writers have copied the Continental ones in calling it a point of *inflexion*.

POISON. Separate articles having been devoted to nearly all the substances which are destructive to life when taken by accident or design, or when administered with a criminal intention, it will be necessary here only to consider the subject of poisons generally, referring to the articles Arsenic, Antimony, Copper, Mercury, Papaver, &c., for the details relating to each of them in particular. The whole subject may be conveniently and usefully treated by pointing out how in any case of legal investigation the proofs of poisoning may be established.

Omitting those things which are common to all cases of suicide or homicide, such as the previous circumstances of the person supposed to be poisoned, the conduct of the accused, and those, however important they may be, that are matters of common evidence, such as a number of persons who have partaken of the same meal being simultaneously and similarly affected, we propose to consider here only how in any individual case the influence of poison may be proved. The chief circumstances in the evidence will be, the symptoms presented during life: the examination of the body after death; the chemical analysis of the substances in which the poison may be mixed; and the experiments by which it is attempted to produce similar circumstances in animals by similar means.

The circumstances that usually first excite the suspicion of poison having been taken are, that the person affected is suddenly attacked by symptoms of severe illness, which come on soon after eating or drinking, without any premonitory indications, which regularly increase in severity without undergoing any important change in their character, and which rapidly prove fatal. All these however are far from affording sufficient evidence of poisoning. Suddenness of attack is common to many disorders, as cholera (whether ordinary or Asiatic), plague, perforating ulceration of the digestive canal, apoplexy, and epilepsy; and even in some cases of fever the premonitory symptoms are too slight to attract the attention of the patient. Any of these too may come on soon after taking food, and while the patient is apparently in the enjoyment of health; this is especially the case with cholera, perforation of the stomach, and apoplexy; and even in some diseases of the heart the patient may seem well up to the instant of the fatal, and often instantly fatal, seizure. The permanency and regular increase of the symptoms is not a more distinctive sign of poisoning. It is equally observed in many cases of the diseases already mentioned, as well as in most acute and uncontrolled inflammations, strangulation or other obstruction of the intestines, &c. Many of these diseases also may prove very rapidly fatal; apoplexy and certain diseases of the heart sometimes destroy life in a few seconds, and often in a few hours; in almost all cases of perforation of the digestive canal, and in some of cholera, death takes place in less than twelve hours.

In no case therefore can these, which are commonly stated as general symptoms of poisoning, excite more than suspicion; they may all have been produced by some spontaneously occurring disease. But on the other hand, the absence of any or all of them is not sufficient to disprove the suspicion of poisoning. Small and often repeated doses of poison may be given so as to produce all their symptoms and death very gradually; and the patient may in such a case exhibit numerous alternations of increase and moderation of the symptoms. Many circumstances will retard the action of even large doses of poison; if a person falls asleep soon after taking one, or if he has taken it with a large quantity of food, or much diluted, or partially neutralised, its symptoms may not be developed for some hours, and may seem quite unconnected with the last occasion of taking food. Or again, the poison may be administered in some other way than with food or medicine, as in the form of a vapour, by applications to the ulcerated skin, &c.

Dr. Christison divides poisons into three classes, irritants, narcotics, and narcotico-acrids. Each of these produce certain symptoms in addition to those already mentioned as belonging to poisons of all kinds, and certain morbid effects upon the organs of the body when it proves fatal, by which their action may in some cases be recognised.

The chief symptoms caused by the internal administration of irritant poisons are those of severe irritation of some or all parts of the alimentary canal. They commonly excite burning heat, redness and swelling and sometimes ulceration of the lining of the mouth, throat, and tongue; difficulty of swallowing, burning pain of the stomach with nausea and retching or vomiting, tenderness on pressure and tension of the upper part of the abdomen. The matters vomited consist, first, of the food or other contents of the stomach, and afterwards of tough mucus with more or less of blood and bile; the sickness is almost incessant, and is usually accompanied by severe suffering. The pain commonly extends from the stomach along a part or the whole of the digestive canal, with tenderness on pressure, and usually a constant and painful diarrhœa of mucus with more or less blood. The pulse is quick and feeble; there is great prostration of strength, excessive burning thirst, cold and damp skin, extreme anxiety of countenance and manner, and often considerable difficulty of breathing.

Many or all of these symptoms occur in all cases of poisoning by irritants, and many of them also in certain diseases, between which and poisoning it may be difficult to discriminate. Of these diseases the most important and deceptive are the acute affections of the digestive organs.

The most general effect of irritant poisoning is acute inflammation of the stomach, and it is therefore a question of the first importance whether that condition is ever produced by any other cause than the administration of poison. M. Louis and Dr. Abercrombie, whose authority is of the greatest weight in subjects of this kind, have stated that they never saw a case of idiopathic and primary acute gastritis; and it is certain that no well-established case of the kind has yet been recorded: the administration of an irritant poison may therefore be regarded as highly probable in any case in which a competent observer finds the signs of an acute inflammation of the stomach during life and its effects after death.

In such cases the principal evidence would depend on the appearances found in the dead body; in others the symptoms during life are equally important. Perhaps of all the diseases which give rise to the suspicion of irritant poisoning, the most frequent is cholera. There are however some circumstances by which they may be distinguished during life. In most cases of this kind of poisoning a burning sensation in the throat is perceived directly after the poison is taken, being the effect of its contact during or soon after the act of swallowing; the same symptom, when it occurs in cholera, appears to be produced by the contact of the substances vomited, and is therefore preceded by some of the other symptoms. In cholera the vomiting is never bloody, and is usually much more profuse than in cases of poisoning; and the cholera that occurs in this country is very rarely fatal in less than three days; while in most cases of poisoning, in which the symptoms are sudden and severe, death ensue in a few hours, or at least before the end of the third day. Asiatic cholera indeed is commonly more rapidly

Poison, or Chambre Ardente. The powers of this court, however, were abused, and very shortly after its institution it was suppressed.

Wherever evidence has been left sufficiently positive to admit of an inquiry into the nature of these secret poisons, it has been found that they contain ingredients well known at the present day. It is only where the sciences of chemistry and medicine are not sufficiently known, or where they are neglected in the inquiry, that secret poisoning can take place. The tests are now so accurate, and the investigations so strict, that it is no longer possible to administer any poison, vegetable or mineral, of which traces cannot be discovered in the body of the person poisoned, though of course it may not always lead to the discovery of the person by whom it was administered.

(Beckmann, *History of Inventions;* Beck, *Medical Jurisprudence;* Adams, *Edinburgh Medical and Surgical Journal,* vol. xxxiii.)

POLAR CLOCK. A portion of the light which passes to the earth under a sky which is clear, or nearly so, is more or less polarised. The maximum effect occurs in a plane passing through the earth's axis at 90° from the sun: hence the amount of polarisation varies in different parts of the sky with the position of the sun. On this relation between the hour-angle and the plane of polarisation of light from the sky, Professor Wheatstone has based his polar clock. It consists of a tube, with the axis parallel to that of the earth passing with gentle friction through an hour-dial. Within the tube is a polarising apparatus, which indicates the position of the plane of polarisation by the vanishing of the coloured rays; and as the plane of polarisation is always 90° from the sun, the index hand attached to the tube, and properly adjusted, will always point to the hour on the disappearance of the colours. The dial is connected with an upright, which moves on a hinge joint, so that by means of a quadrant and a clamping screw it can be adjusted to the latitude of the place of observation.

POLAR LIGHTS. This subject, that of the *Auroræ Borealis* and *Australis,* will be treated of under the appellation in which they were included by Humboldt, TERRESTRIAL LIGHT.

POLARITY signifies, in general, a disposition in a body or in an elementary molecule of a body to place its mathematical axis in some particular direction; frequently also it denotes in a body the existence, either naturally or induced, of two points possessing contrary properties.

If iron-filings be strewed over a mass of natural loadstone, it will be found that there are two points on its surface at which the filings are most abundantly attracted, and where they dispose themselves nearly in the direction of a line imagined to be drawn through the mass. [MAGNETISM.] Then, if the loadstone be cut in the form of a sphere, having this line for a diameter, the symmetrical arrangement of the iron-filings with respect to this line affords an indication that the particles of the loadstone may be symmetrically disposed about the line; and, from an analogy with the axis and poles of the earth, this line is called the axis of the loadstone, and its extremities are called the poles. If the mass of loadstone be cut in the form of a prism, the length of the latter being in the direction of the axis, and if the prism be suspended by its centre of gravity, it will be found to take one particular direction with respect to the horizon and the meridian of the observer. The two extremities of the prism so formed have received the denomination of poles, and the term is now applied to the opposite extremities of any body or molecule, when it assumes or can be brought into a particular direction.

What has been said respecting the properties of a prism formed of the natural loadstone, is true of a magnetised bar of steel [MAGNET], and the poles or opposite extremities of either material are found to possess a contrariety of character. One extremity always tends towards the northern part of the horizon only, and the other towards the southern part; and if two such prisms or bars are formed, and suspended by their centres of gravity, on bringing the northern or southern pole of one near the like pole of the other, they exercise upon each other a mutual repulsion; but if either pole of one be brought near the opposite pole of the other, they mutually attract each other.

Since in magnetised bars the poles of contrary names thus attract each other, and that the earth may be considered as a body possessing boreal magnetism towards the north, and austral magnetism towards the south, it is evident that the magnetism which exists in the northern extremity or pole of a suspended bar (as a compass needle) must be *austral,* and that which exists in the southern extremity must be *boreal.*

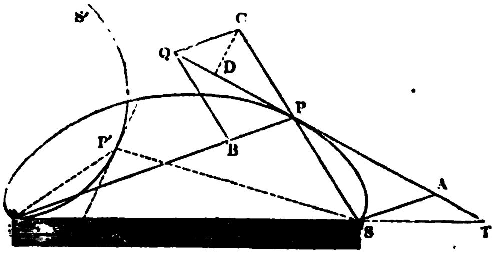
If a cylinder of wood or metal be insulated on a glass stand, and it be then brought near a body which has been electrified by the usual machine, it will be rendered polar; that is, one end will possess the vitreous or positive electricity, and the other the resinous or negative electricity, and near the middle the cylinder will be in a neutral state. These conditions may be rendered evident on electrifying a pith ball, insulated by means of a silk thread, and presenting it to the cylinder, when it will be attracted towards one end and repelled from the other. It appears, from the effect of the cylinder on the electrified ball, that the particles of fluid of the same kind repel each other, and those of unlike kinds attract each other.

Polarity is also obtained by galvanic electricity. In an ordinary battery, the fluid, by chemical action on the zinc, produces a separation of the two kinds of electricity; that which is called positive is carried to the copper plate, and the latter communicates it to the zinc plate with which it is connected. This action is repeated at every pair of plates in the battery; and from the last zinc plate the electricity enters the conducting wire, or that which is employed to connect the opposite extremities of the battery: thus the zinc extremity constitutes the positive pole of the battery. At the same time an opposing current of negative electricity passes from the copper, through the fluid, to the zinc, from thence to the next copper plate, and so on to the last, which is in connection with the conducting wire at that extremity of the battery; this copper end is called the negative pole of the battery. [GALVANISM.]

The attractive power in a magnetised steel bar increases from each extremity to about one-quarter of an inch from thence, where it is the greatest, and it then diminishes gradually towards the centre; this distribution is similar to that of the induced electricity in the insulated cylinder. But experiments show that if a prism of loadstone or a magnetised bar be divided into several parts, perpendicularly to its length, each part is a complete magnet, having poles of contrary denominations at its extremities; and this condition is accounted for by Coulomb in the following manner:—He supposes that every molecule of loadstone is a small magnet possessing opposite polarities at its extremities, the axes of all being parallel to or coincident with the magnetic axis of the mass; and that a similar disposition of the molecule is induced in a bar of steel when the magnetic power is communicated to it. The austral polarity of each molecule, while in the mass, is destroyed by the boreal polarity of that which is contiguous to it in the common directions of their axes; but on separating, as above, the parts of the loadstone or magnetised bar, that extremity of each which is farthest from the northern pole of the bar exhibits the austral magnetism appertaining to the like extremities of the molecules; and that extremity which is nearest exhibits boreal magnetism.

A magnetised steel bar, when tried by means of a small compass-needle, is often found to exhibit, at different places in the direction of its length, a change from boreal to austral magnetism, and the contrary. These places are called consecutive poles.

The intensity of the force, either of attraction or repulsion, exercised by one of the poles of a magnet on any body is inversely proportional to the square of the distance of such body from that pole; and if a very small compass-needle, supported or suspended in the usual way, be brought near a magnetised bar, it must settle, between those opposing forces, in the direction of a tangent to some curve line passing through the two poles of the magnet. This is called the magnetic curve, and the direction of the tangent at any given point may be thus investigated:—



Let N be the north and S the south pole of a magnet; let P be any given point at which the centre of gravity of a small suspended needle may be placed, and join PN, PS. Let the attraction of N on P be expressed by $\frac{1}{PN^2}$ and be represented by PB; also let the repulsion exercised by S on P be expressed by $\frac{1}{PS^2}$, and be represented by PC, in the direction of SP produced. Imagine the parallelogram CB to be formed; then, by mechanics, PQ, its diagonal, will represent the resultant of the forces acting on a particle at P; it will therefore be the direction of the needle and of a tangent to the curve at that point. Let ∠ QPC be represented by θ; ∠ QPB by θ', and let fall CD perpendicularly on PQ: then by trigonometry, $\frac{\cos. \theta}{PS^2}$ is the value of PD, or the equivalent of the force represented by PC when reduced to the direction PQ; and $\frac{\cos. \theta'}{PN^2}$ is the value of QD, or of the force PB (=QC) when reduced to the same direction. The sum of these, or $\frac{\cos. \theta}{PS^2} + \frac{\cos. \theta'}{PN^2}$, is the value of PQ, and represents the whole force of the magnet on the point P in the direction of that line: hence,

$$PQ^2 = \frac{\cos.^2 \theta}{PS^4} + \frac{\cos.^2 \theta'}{PN^4} + 2\frac{\cos. \theta \cos. \theta'}{PS^2 . PN^2}.$$

But, by geometry, $PQ^2 = PC^2 - QC^2 + 2 PQ . QD$ which, by substitution becomes $\frac{1}{PS^4} - \frac{1}{PN^4} + 2\left(\frac{\cos.\theta}{PS^2} + \frac{\cos.\theta'}{PN^2}\right)\frac{\cos.\theta'}{PN^2}$. Equating these values of PQ^2 and leaving out terms which destroy each other, we have $\frac{1}{PS^4} - \frac{\cos.^2\theta}{PS^4} = \frac{1}{PN^4} - \frac{\cos.^2\theta'}{PN}$; whence $\frac{\sin.\theta}{PS^2} = \frac{\sin.\theta'}{PN^2}$, and $\sin.\theta : \sin.\theta' :: PS^2 : PN^2$.

Now, produce QP till it meets NS, produced, if necessary, in T; and draw SA parallel to NP: then, by trigonometry,

$$SA : PS :: \sin. APS : \sin. PAS :: \sin. QPS : \sin. QPN; \text{ that is,}$$

$$SA : PS :: \sin.\theta : \sin.\theta'; \text{ hence}$$

$SA : PS :: PS^2 : PN^2$, which being compounded with the identical proportion $PS : PN :: PS : PN$ gives

$$SA : PN :: PS^3 : PN^3.$$

But SA being parallel to PN, $SA : PN :: ST : NT$; therefore $ST : NT :: PS^3 : PN^3$.

Thus the ratio of ST to NT is known; and, consequently the position of the tangent PT, from the given position of P. If the poles N and S are unlike, as above supposed, the curves are of the kind called convergent, as NPS; but if the poles are similar, the curves will be divergent, as NP′S′.

POLARIZATION OF LIGHT,
POLARIZATION, MOVEABLE,
POLARIZED RINGS,
} will be found at the end of letter P.

POLDERS. The meadow lands by the side of rivers, or of the sea-shore, which are only protected from inundation by means of enclosure dykes, banks, or walls, are known on the Continent by the name of Polders; and in Holland, where these hydraulic works are the most common, they are further subdivided into the schorres, the maritime polders, the boezem landen, and the drained lakes. The various works connected with these modifications of polders will be discussed under RIVER ENGINEERING, and SEA DEFENCES. For the present, it may suffice to say that the polders almost invariably require a complete enclosure, with an interior collecting drain for the land waters, which are discharged directly through sluices, or outfall gates, or are lifted over the bank by windmills or other mechanical means. The polders are, generally speaking, used as grazing land for horned cattle, or at times for the growth of rape or other oleaginous grains: of course the cattle are withdrawn from them during the winter months. The superintendence of the works for the defence and maintenance of the polders in North-Western Europe is entrusted to local administrations, or syndicates, acting under the control of the respective departments of public works in the countries where those polders exist.

POLE. [PERCH.]

POLE, POLAR. The word πόλος as applied to a point means a turning or hinge point, and was applied to the points at the extremity of the axis of the celestial sphere in the ancient astronomy. Hence, on the hypothesis of the earth's rotation, it comes to mean the extremities of the axis on which the earth turns. From this primary meaning all the various uses of the word pole have been derived. For example, when it was found that the magnet did not always point to the north pole, but to another point, it was natural to call that other point the *magnetic* pole. Previously to this use of the word, it had already taken a wider signification, as follows:—On looking at the position of the equator with respect to the poles, it is obvious that if the equator, or circle of equal day and night, should be changed, the axis must also be changed, and the poles of rotation. Hence any great circle of the sphere is said to have its poles, meaning those points which would become poles of rotation if that circle became the equator. [SPHERE.]

A term seldom passes through several significations, however nearly related, without at last becoming generic in the widest sense. The word pole is now used to denote any point which is of so striking a character as to require a distinct name. In physics the word is naturalised in magnetism, electricity, and optics; insomuch that any tendency towards a particular point, or even towards a particular direction, is termed polarity. In geometry, the only definition which can now be given of this term is, that it means any point which it is wanted to mean. Thus a point considered as the origin of CO-ORDINATES is called the pole; and when distances measured from the origin are among the co-ordinates, they are called polar. Again, it is a well known property of the conic sections, that if all possible chords be drawn through any one given point, and a pair of tangents be drawn from the extremities of each chord, the intersections of all the pairs will lie in one straight line; the point through which the chords are drawn is called the pole of that straight line.

POLE STAR. [URSA MINOR.]

POLEMARCH. [ARCHON.]

POLICE is that department of government which has for its object to secure the safety, peace, and convenience of the community. We have here to do with this its primary object, namely, the prevention of crime and the pursuit of offenders; but besides this the police system is subservient to other purposes, such as the suppression of mendicancy, the preservation of order in great thoroughfares, the removal of obstructions and nuisances, and the enforcing of those local and general laws which relate to the public health and comfort. [MUNICIPAL CORPORATIONS.]

In the Anglo-Saxon times the whole community was called upon to aid in protecting life and property; and the spirit of this system, though the system is no longer applicable to the existing state of society, still characterises this department of our institutions. The object of the present notice will be to give some account of the former and present constitution of the police in England.

In the Anglo-Saxon period the sheriff of each county, chosen by the freeholders in the folkmote, was the chief officer responsible for the conservation of the peace; and in his half-yearly visitations to each hundred in the county, he inquired whether there was any relaxation in the efficiency of the means in use for this object. The hundred originally consisted of ten divisions, each containing ten freeholders, mutually pledged to repress delinquencies within their district. All males above the age of twelve were obliged to appear at the sheriff's visitation, to state the district to which they belonged, and to be sworn to keep the peace. One out of every ten freeholders had precedency of his companions, and the whole were bound to bring delinquents to justice within thirty days on pain of being themselves liable to penalties. The population was thinly scattered; every man was known to his neighbours; no man could depart from his dwelling without the consent of his fellow-pledges; and the consent of the sheriff was necessary to enable a man legally to go out of his own county. No man could enter a neighbourhood without being recognised as a stranger, and probably exciting suspicion; and this suspicion, quickened by the responsibility of the freeholders, soon caused a hue and cry if the stranger could give no good account of himself. [HUE AND CRY.]

After the Conquest, the advantages of the system were recognised by several of the Norman kings, particularly by William I., and by Henry I. in the early part of his reign. The former ordered that every freeman should be under pledges, and the latter that views of frank pledge should be taken in order that none might escape responsibility. But a great innovation was made in the Anglo-Saxon system when the sheriff, instead of being elected by the freeholders, was appointed directly by the king. Doubtless he would generally be a Norman, and therefore indisposed to meet the people in their popular courts: at all events the sheriff's "tourn," or half-yearly visitation, came in no long time to be neglected.

When Henry I. instituted the office of justices-itinerant [CONSERVATORS OF THE PEACE], the functions of the sheriff became of still less importance. By the stat. Merton, c. 10, passed 20th Henry III. (1236), freemen who owed suit to the county or hundred court were allowed to appear by attorney. The stat. Marl. cc. 10 and 25 passed in the 52 Henry III. (1268), dispensed with the attendance of the baronage and clergy at the sheriff's court unless their attendance was specially required; and it also prohibited the justices-itinerant from amercing townships on account of persons above the age of twelve years not having been sworn in pledges for keeping the peace. By these various measures the ancient system was greatly impaired; and the new laws which were introduced from time to time for the purpose of repressing crime do not seem to have been very successful. In 1277, nine years after the passing of the statute of Marlebridge, the absence of "quick and fresh pursuit" of felons is noticed as an evil which was increasing. To supply the energy and alacrity of the old system, fines and penalties were imposed by the stat. Westminster, prim. 3 Edward I., sec. 9, on all who neglected to pursue offenders. The statute directs that "all generally be ready and apparelled at the commandment and summons of the sheriffs, and at the cry of the county, to pursue and arrest any felons when any need is." The statute of Winchester, 13 Edward I. (1285), endeavoured to maintain the spirit of the Anglo-Saxon laws by making the county or hundred responsible in case of a delinquent not being forthcoming, and the duty of apprehending him was cast upon all the king's subjects. This statute also regulated the office of constable, an officer who had succeeded the Anglo-Saxon hundred or tything-man. [CONSTABLE.] The constables were directed what measures they were to take for preventing crime and keeping the peace. In every town, village, and tything they were to set a watch according to the size of the place, every night from Ascension till Michaelmas, from sunset to sunrise; and the watchmen were to apprehend and examine all strangers, and on their refusal to obey the summons of the watchmen, they might levy hue and cry to take them. The gates of all walled towns were to be shut from sunset to sunrise: the highways were to be kept clear of bushes, woods, or dykes for the space of two hundred feet from hedge to hedge, so that felons might not conceal themselves. Every man was to have arms in his house for preserving the peace; and the constables were empowered to take the view of such arms. The prevention of crime, as well as the pursuit of criminals, was also one of the primary duties of constables, and they were charged to make presentment at the assizes, sessions of the peace, or leet, of all blood-sheddings, affrays, outcries, rescues, and other offences against the peace. The justices to whom these presentments were made in the first instance, reported directly to the justices-itinerant, or at once to the king or his privy-council; and the supreme executive made provisions accordingly. At the same time the responsibility cast upon the hundred quickened the vigilance of the inhabitants; and this responsibility extended to individuals in many cases. The following extracts from the Year-Books of the Exchequer are instances of this: "16 Edward I., Sussex: murder and robbery—township of Tyndon amerced, because it happened by day, and they did not take the offender." "6 Edward II., Kent: manslaughter (upon a sudden quarrel) committed in the highway of Wrotham—three bystanders amerced because they were present when the aforesaid Robert killed the aforesaid John, and did not take him." And in the reign of Elizabeth the popular vigilance which this system had created leads a writer of that day to remark that "every Englishman is a serjeant to take the thief, and who showeth negligence therein do not only incur evil opinion thereof, but hardly shall escape punishment." Thus, when the Anglo-Saxon system of mutual protection had fallen to decay, the spirit of vigilance which characterised it was in some measure replaced by the greater energy and activity of the supreme executive. In process of time, however, great social and political, and, it may be added, physical changes have rendered both systems equally incapable of effecting the objects for which they were intended.

In the year 1829, the late Sir Robert Peel, after having consolidated the Criminal Law of England, instituted in the metropolis the new police force, which more than any other external means has consolidated peace and protected life and property, to the undoing of invective such as met its introduction, and to the disappointment of all the alarm that was excited by it for the liberty of the subject. This was effected by the 10 Geo. IV., c. 44; and that Act was followed by the 2 & 3 Vict. c. 47, making further improvements in the force, extending the metropolitan police district to a radius of fifteen miles from Charing Cross, and giving police-jurisdiction over the river Thames, and the quays and docks existing thereon. The city of London, that had been exempted from the operation of these statutes, was by the 2 & 3 Vict. c. xciv., provided with a similar force under a special commissioner, entirely under the control of the city authorities. And other cities and boroughs from this time forward successively acquired by private Act of Parliament the necessary powers to enable them to institute and maintain police on the model of the metropolitan force. By the 5 & 6 Vict. c. 109; 7 & 8 Vict. c. 52, and 13 & 14 Vict. c. 20, petty constables for preserving the peace in parishes or townships maintaining their own poor, and in extra-parochial places, are to be chosen annually by the justices of the peace for the district or division, from a list made by the overseers, comprising every able-bodied man between 25 and 55 years resident in the parish, and rated to the poor rate or county rate, or holding at the yearly rent of 4*l.*, subject, however, to sundry exceptions expressly mentioned in the Act. This was a resuscitation of the ancient constabulary for the protection of life and property, and maintenance of the queen's peace, in places and districts not incorporated, the inhabitants themselves, in the true spirit of old English institutions, being thereby mutually engaged under oath, without remuneration, to the performance of this important public duty.

The 2 & 3 Vict. c. 93, and the 3 & 4 Vict. c. 88, had in the meantime provided for the appointment of county constabulary, clothed, paid and accoutred, and formed in accordance with rules prescribed by the Secretary of State for the Home Department. But as these Acts left the initiative in the discretion of the county magistrates, very many of the English and Welsh counties continued to be without protection, save such as was afforded by the parish constable, until the 19 & 20 Vict. c. 69 (20 Vict. c. 2) made it compulsory on the magistrates of every county where no police had yet been constituted, to proceed therein forthwith. Powers for the consolidation of independent bodies of police already existing, or for the joint appointment and superintendence of police for adjoining districts and boroughs, were given by the same statute, and provision was made for imposing one-fourth of the expense of the force, whenever it was efficient, on the Consolidated Fund. Similar provision had already been made by the 3 & 4 W. IV., c. 89, for advancing a sum of 60,000*l.* a year out of the Consolidated Fund towards defraying the expense of the metropolitan police. In this way the whole of the country, by successive steps, and in virtue of a series of statutes, beginning with the Act of Sir Robert Peel in the tenth year of George IV., has at length been placed under the protection of a well-devised and very efficient system of police, whose surveillance of the country is continued throughout the whole of the four-and-twenty hours. In Scotland the larger towns have many of them separate police statutes, placing the management and control of the system in the hands of elected commissioners; but the 3 & 4 Wm. IV. c. 46, a general police Act, the provisions of which, or a portion of them, might have been adopted by any royal burgh, burgh of regality, or burgh of barony, at a meeting of a specified number of ten-pound householders, has been adopted in several places. That Act was amended by the 10 & 11 Vict. c. 39, and further by the 13 & 14 Vict. c. 33, and, thus amended, is still in full force and operation. The 20 & 21 Vict. c. 72, however, has since been passed for improving the police system of Scotland, and providing facilities for the establishment of police where none at the time existed. As in the general Act for England, the institution of county constabularies is by this Act compulsory on the commissioners of supply for each county; provision is also made for the consolidation of independent bodies of police, and for the establishment of police for neighbouring districts and burghs jointly. The former statute, the 2 & 3 Vict. c. 65, which left it discretionary in the commissioners of supply to provide constables for the counties, is repealed; and provision is made for charging one-fourth of the expense of any burgh or county constabulary, reported to be efficient for the year in numbers and discipline, on the Consolidated Fund.

POLICY and POLITY. Policy is generally used to signify the line of conduct which the rulers of a nation adopt on particular questions, especially with regard to foreign countries; and according to our opinion of that particular line of conduct, we say that it is good or bad policy. Polity has a more extended sense, being synonymous with the principles of government, and this is the sense of the Greek "politeia" (πολιτεία), from which it is derived. Police, in an extended sense, is that branch of polity which is concerned with the internal economy of the state. In a more restricted sense, it is a branch of preventive administration, distinct from the administration of justice, the object of which, among other things, is the punishment of crimes committed.

POLICY. [Reversion.]

POLIENE. [Melam.]

POLISHING. [Cutlery; Gilding; Varnish.]

POLITICAL ECONOMY is the name given to a department of knowledge the limits of which are not yet accurately defined. The word economy, applied to domestic concerns, means the art of well administering the private affairs of a family, of regulating its expenditure according to its income, and providing for the wants of the members of the household. By analogy, political or "public" economy has been considered by many as conversant about the principles of administering the wealth of a country with a view to its increase, regulating the expenditure, providing for the wants of the people, and endeavouring to maintain and increase their comforts. But by taking such an extensive view of the subject, most writers, and especially continental writers, have considered it necessary to investigate all the causes of the prosperity of nations, and have involved themselves in multifarious discussions on the various forms of government and of civil institutions which are supposed to affect the economical condition of a people. By so doing they have encroached upon the science of general politics and legislation, and have brought forward their own theories of laws, ethics, and administration, with the view of showing their influence on the social state. But it is evident that such a vast field of inquiry must exceed the powers of any single writer, and that the attempt to embrace so many difficult and varied subjects under one division of knowledge, tends to confuse rather than to elucidate. Modern writers, especially in England, have therefore limited their inquiries to the principles which govern the production and accumulation of wealth, and its distribution and consumption. "The Wealth of Nations" was the title which Adam Smith gave to his work. In this consists the main difference between the modern English and the Italian and French economists. The latter maintain that the political economist is concerned not only with the aggregate production of wealth, but with its most beneficial distribution among individuals, not only with wealth in short, but with happiness also. The modern English writers, on the contrary, say that the appropriate subject of the political economist is not happiness, but wealth; that wealth is confined to material objects, the produce of land and of industry; that the political economist who assumes to explain the phenomena of the production of wealth ought to lay down the general principles on which wealth is produced, as they are deducible from actual facts; it is the business of the statesman, the philosopher, or the politician, to say what he thinks best for the general prosperity of society, after he has examined the evidence of the political economist, which is an essential part of the evidence, but not the sole evidence to be attended to in the conduct of a nation's affairs. But here the English economists also seem to be divided among themselves. Some appear to think that the principles of political economy, as the term is understood by them, may be deduced with the certainty of mathematical demonstration, whilst others assert that there are many important propositions in political economy which require limitations and exceptions. "The desire to simplify and generalise has occasioned an unwillingness to acknowledge the operation of more causes than one in the production of particular effects; and if one cause would account for a considerable portion of a certain class of phenomena, the whole has been ascribed to it without sufficient attention to the facts which would not admit of being so solved." (Malthus, 'Principles of Political Economy,' Introduction.) Malthus quotes the controversy on the bullion question as an instance of this kind of error.

We cannot enter into anything like an examination, however brief, of the principles of political economy; but shall merely state a few general propositions which are universally acknowledged as true. 1. Every man desires to obtain additional wealth with as little trouble to himself as possible. 2. The increase of population is limited either by physical or moral evil, or by prudential motives. 3. The powers of labour, and of the other instruments which produce wealth, may be indefinitely increased, by using their products as the means of further production. 4. Agricultural produce is not susceptible of the same unlimited increase as manufactures. The principal topics discussed by political economists are: 1, the definition of wealth; 2, of productive and unproductive labour; 3, of the nature and measures of value; 4, of the rent of land; 5, the wages of labour; 6, the profits of capital·

7, the results of machinery; 8, the circulating medium, or currency; 9, the nature and conditions of commerce, or exchange of commodities. Most of these subjects are treated in this work, under the heads ACCUMULATION, BALANCE OF TRADE, BULLION, CONSUMPTION, CURRENCY, EXCHANGE, PROFIT, RENT, WAGES, WEALTH.

History of the Science.—The great nations of antiquity, the Greeks and Romans, had no notion of what we understand by political economy. They sought to increase their wealth chiefly by war, by conquering and plundering weaker nations, and appropriating to their own use part of the produce of their industry. They considered handicraft and trade as degrading to a citizen, and left those pursuits to be exercised by slaves or freedmen. The Romans, in the earlier ages of the republic, held agriculture in more esteem; but after they had extended their conquests beyond the limits of Latium, the business of agriculture also was mainly conducted by slaves. The consequences of this system are well known; agriculture declined, and the people of Rome were obliged to be fed by corn from the provinces. It is evident that in such a state of society there will be no room for the consideration of some of the most important questions of political economy, which are based upon the principles of free labour and competition. It appears that the Romans considered gold not as the representative of wealth, but as wealth itself, for we find that the senate forbade its exportation. (Cicero, 'Pro Flacco,' 28.)

After the fall of the Roman empire, the free towns that rose in the middle ages, Pisa, Venice, Florence, Genoa, and the Hanseatic towns, were essentially commercial, and with them the "mercantile" system, as it is called, may be said to have originated, at least in practice; for it was not expounded and reduced to rules until centuries after. This system consisted in looking to foreign trade as the source of wealth, selling dear and buying cheap, and thereby realising, by the exchange, a surplus in bullion, which surplus was employed in increasing the quantity of produce to be sold. Shipping, foreign marts, colonies or factories abroad, were the means employed for these objects. But as each mercantile nation sought a monopoly of trade, restrictions were resorted to in order to favour its own commerce and impede or depress that of others. This led to jealousies and wars, which ended with the ruin of one or the other of the contending parties. This system was narrow and exclusive: it considered only one state, and built the prosperity of that state on the depression of others. It was affected by the same error as the military system of conquerors, who wish to exalt and enrich one country by subjugating and plundering another, overlooking the fact that the prosperity of other countries is part of the general prosperity of the world, in which our own country must share. The principle that "the whole world as to trade is but as one nation or people, and therein nations are as persons" (Sir Dudley North's 'Discourses on Trade,' 1661), was not known as yet, and indeed it may be said to be acknowledged, even now, by comparatively few in any country.

Another mistake of the states of the middle ages was that of considering gold and silver as constituting the exclusive wealth of a country; their attention was fixed on money not as a means, but as the end of trade, and as the most beneficial surplus, which they endeavoured to retain in their coffers by enacting severe penalties against its exportation. Hence the earlier Italian writers on commerce treat exclusively of money, its standard, and the evils of tampering with it. Gasparo Scaruffi, of Reggio near Modena, wrote, in 1579, 'Discorso sopra le Monete, e della vera proporzione frà l'oro e l'argento.' In 1588 Bernardo Davanzati of Florence wrote a short treatise, 'Sulle Monete,' and another 'Sui Cambj,' or 'The Exchanges.' Antonio Serra, a native of Cosenza in Calabria, published, in 1618, 'Breve Trattato delle Cause che possono far abbondare i Regni d'Oro e d'Argento.' Looking upon gold and silver as constituting the wealth of a state, Serra investigates the means of making them flow abundantly into a country. Among these means he reckons manufactures, "which afford a much greater return than agriculture;" and maritime commerce. But "these means," adds Serra, "are of no avail without fixed laws, order, and security for persons and property, for there can be no prosperity where there are continual changes of dynasties and laws." This shows that Serra, considering the age and country in which he lived, had formed some correct and extended notions of political economy. His book however remained unnoticed, and the author, being implicated, as it seems, in some conspiracy against the Spanish rulers of Naples, was imprisoned for ten years, and underwent the torture seven times. It is not known when and where he died. Turbolo of Naples wrote several treatises on the coinage and the state of money in the kingdom of Naples; 'Discorsi e Relazione sulle Monete del Regno di Napoli,' 1616, 1618, 1623, and 1629. Geminiano Montanari of Modena published, in 1680, 'Trattato Mercantile delle Monete,' and afterwards, 'Trattato del Valore delle Monete in tutti gli Stati,' in which he lays down sound principles for regulating the coinage.

The first writers on the subject of commerce at large appeared in England. Raleigh wrote, in 1595, his 'Essay on Trade;' Edward Misselden wrote his 'Circle of Trade,' in 1623, and Louis Roberts his 'Treasure of Traffic,' in 1641. Thomas Mun wrote, in 1621, his 'Defence of the East India Trade,' in which he exploded the notion that money exclusively constituted wealth. He compared the exportation of gold and silver wherewith to buy goods for importation, with the seed which the husbandman throws into the earth that he may reap a plentiful harvest; and in his 'Treasure of Foreign Trade,' published in 1664, Mun advocates the same principle. But Sir William Petty went further than any of his predecessors or contemporaries in asserting enlarged views of political economy. In his treatise 'On Taxes and Contributions,' published in 1667, he was the first to state, though in an incidental manner, that "it was the labour required for the production of commodities which determined their value." He also wrote his 'Quantulumcunque,' a treatise on money, in which he condemned the laws regulating the rate of interest, and combated the notion that a country may be drained of cash by an unfavourable balance of trade. [PETTY, SIR WILLIAM, in BIOG. DIV.]

In France, the minister Colbert, a contemporary of Sir William Petty, was a great promoter of the mercantile system in all its exclusiveness [COLBERT in BIOG. DIV.], and the principles of that system continued to prevail in France after his death till the time of Quesnay. Pierre le Pesant, Seigneur de Bois Guibert, published, in 1695, his 'Détail sur la France,' in which he treated both of commerce and money, but the author was banished because some of his propositions reflected upon feudal rights and ecclesiastical privileges. Twelve years later Vauban published his 'Dixme Royale,' in which he proposed a new plan of taxation.

In England, Locke, in his 'Essay on Civil Government' (b. xi., 40-48), argued at length to prove that "labour is the constituent principle of value." There is something to the same purpose in Hobbes's 'Leviathan' (ch. 24). But these were incidental remarks, and not professed investigations on the subject of political economy.

In a tract published in 1677, entitled 'England's Great Happiness,' the notion of the balance of trade is examined and its fallacy exposed. [BALANCE OF TRADE.] Sir Dudley North wrote 'Discourses on Trade,' 1691, which contain more clear and comprehensive notions on trade than had yet been published. Among other propositions, he lays it down as a maxim that "there can be no trade unprofitable to the public; for if any prove so, men soon leave it off, and wherever the traders thrive, the public, of which they are a part, thrive also." It is worthy of notice, by way of contrast, that Montesquieu in the following century wrote a chapter entitled 'To what Nations Commerce is prejudicial.' ('Esprit des Lois,' b. xx., ch. 21.) In 1696 Davenant wrote on 'the Commerce and Revenue of England.' In the next century Sir Matthew Decker wrote an 'Essay on the Causes of the Decline of Foreign Trade,' 1744.

A change of opinion was in the meantime taking place on the Continent with respect to the so-called "mercantile system." François Quesnay, born in 1694, a medical man by profession, and surgeon to Louis XV., being struck by the distressed condition of the French peasantry, endeavoured to draw the attention of the government towards relieving that numerous and ill-used class of people. He proposed the abolition of custom-houses between province and province, the free circulation of corn throughout the kingdom, the suppression of the corvées, and other similar reforms, which were effected after his death by Turgot. Quesnay went further: he assumed as a principle that the earth, or in other words, agriculture, was the only source of wealth, in opposition to Colbert's mercantile system, which fixed that source exclusively in trade. Quesnay allowed that manufactures and merchants were highly useful, but he contended that as they realised no net surplus in the shape of rent, they did not add any greater value to the raw material of the commodities which they manufactured or carried from place to place, than was just equivalent to the value of the capital or stock consumed by them during the time that they were engaged in those operations. He divided society into three classes: 1, a productive class, consisting of farmers and agricultural labourers, who subsist on a portion of the produce of the land, reserved to them as wages of labour and as a reasonable profit on their capital; 2, a proprietary class, namely, those who live on the rent of the land, or the net surplus produce raised by the cultivators, after the necessary expenses have been deducted; 3, an unproductive class, consisting of manufacturers, merchants, servants, and handicraftsmen, "whose labour, though useful, adds nothing to the national wealth, and who subsist entirely on the wages paid to them by the other two classes." (Quesnay, 'Physiocratie, ou Constitution Naturelle des Gouvernemens,' 1768.) As a corollary to these positions, Quesnay and his disciples concluded that all taxes ought to fall upon the land.

Quesnay is considered as the head of the school called the school of the "Economistes," which reckoned amongst its members the Marquis de Mirabeau, father of the celebrated Mirabeau, Mercier de la Rivière, Dupont de Némours, Condorcet, Raynal, Turgot, Necker, and other distinguished men.

Quesnay's principal work on political economy is the 'Physiocratie' already mentioned; but he published other tracts, especially an article 'Sur les Grains,' which was inserted in the 'Encyclopédie,' and in which he advocates the same principles. Though Quesnay considered agriculture as the only source of wealth, he did not advocate any exclusive protection for it, but rather a principle of freedom in all branches of trade. The "Economistes" originated the "Cadastre," which was a survey and valuation of all real property, made by order of the government, for the purpose of assessing the "contribution foncière," or property tax, which they considered as the only legitimate tax. And this principle has prevailed in France and other continental countries, where even now the tax on land and houses forms the main source of the public revenue, being from 20 to 30 per cent. on the rent.

In Italy, Antonio Bandini of Siena had asserted the fundamental principle of the "Economistes," long before Quesnay, in a work which however was not published till 1775. Bandini wrote his 'Discorso Economico' in 1737, with a view of drawing the attention of the Tuscan government to the desolate condition of that vast tract of country called the Maremma of Siena. Bandini advocated freedom of trade in agricultural produce, and recommended the removal of all restrictions upon importation and exportation; he urged the expediency of giving to the cultivators of the soil an interest in the land, by the grant of long leases; and lastly he recommended the removal of the numerous vexatious taxes, and the substitution of a single tax upon land, not excepting ecclesiastical and other privileged property. A MS. copy of Bandini's book was presented to the grand-duke Francis of Lorraine, who however, being soon after elected emperor of Germany, and having removed to Vienna, could not attend to the affairs of the Maremma. But his son Leopold, on coming to the government of Tuscany, consulted Bandini's work, and put into execution the plan therein proposed. The Maremma of Siena assumed a new life, and its population nearly trebled in the course of half a century.

Antonio Broggia of Naples, a merchant by profession, wrote a treatise on taxation, 'Sul Tributi,' in which he admits that there are three sources of wealth, agriculture, handicraft or manufactures, and commerce. He does not consider the tax on land as the only legitimate tax, but proposes three sorts of taxation, land-tax, customs, and gabelle or excise. He says that in a great commercial country the customs and excise, or indirect tax, ought to be preferred, but in an agricultural country like Naples the tax on land must be the principal source of revenue. He condemns taxes on capital and persons, licences and patents, horses and agricultural implements, as detrimental to industry, as well as the government monopolies of salt, tobacco, &c. The author, who belonged to the mercantile school, falls into the error of that school, in wishing to sell as much as possible to foreigners, and buy as little as possible from them.

Ferdinando Galiani also, of Naples, ranks among the most distinguished writers on political economy in the last century. While at Paris, he wrote in French a book on the corn-trade, 'Dialogues sur le Commerce des Blés,' in which he took a middle course between those who advocated an unrestricted trade in corn, and those who wished it to be subject to permanent restrictions. Galiani contends that no universal system can be established on that important subject, and that the laws concerning the trade in corn must vary according to the situation of individual states, the nature and cultivation of their respective soils, and also their political institutions and relations to other countries. Galiani also wrote, in Italian, a work on money, 'Della Moneta,' published in 1750, which is reckoned one of the best on this subject. Taking an enlarged view, he investigated the nature of the value of things, which he said was the result of various circumstances, namely, their scarcity, utility, the quantity and quality of the labour required for their production, and also the time. He extends his investigations to the value of men's abilities, which are to be estimated not only according to their rarity, but also according to the time required for their coming to maturity, and the difficulties encountered before they can attain a station favourable to their development. This is a position analagous to that afterwards stated by Adam Smith (b. i., ch. 10), "that the wages of labour vary with the easiness and cheapness or the difficulty and expense of learning a business." It requires more time and expense to form a physician, or a statesman, or a divine, than a common labourer, and therefore the latter has less value than the former. Galiani combats the received opinion of his time, that high prices were a sign of distress. He also contended that the precious metals were to be considered as merchandise. Galiani may be considered as a reformer of the old mercantile system. [Galiani, in Biog. Div.]

Gian Francesco Pagnini, born at Volterra in 1715, published in 1751 a dissertation 'Sopra il giusto Pregio delle Cose,' or the just value of things, and in 1764 a 'History of the Commerce of Florence,' with a digression on the value of gold and silver, and its proportion to the prices of other things in the 14th and 15th centuries, compared with those in the 18th century. Both works contain sound opinions and interesting facts. Pompeo Neri of Florence wrote, in 1751, 'Osservazioni sopra il Prezzo legale delle Monete,' a work of considerable merit.

Gian Rinaldo Carli, born at Capo d'Istria in 1720, ranks with Galiani as one of the most distinguished Italian political economists. He wrote an elaborate work on coin and currency, and on the mints of Italy: 'Delle Monete e della Istituzione delli Zecche d'Italia,' 3 vols. 4to., 1754-60, in which he completely exhausted the subject. Carli also wrote 'Ragionamento sopra i Bilanci Economici delle Nazioni,' in which he combated the fallacy prevalent in his time about the balance of trade. He also discussed the subject of the corn-trade in a letter addressed to Pompeo Neri, in 1771, 'Sul Libero Commercio dei Grani,' in which he agreed with Galiani in denying the wisdom of a general principle of unrestricted freedom of trade in corn, which he thought ought to be modified according to local circumstances, because he considered the supply of corn as a subject deeply connected with administrative policy, and not a mere commercial question. Carli had a powerful mind, uninfluenced by popular opinions or prevalent systems. Other particulars concerning this distinguished writer are given under Carli, in Biog. Div.

Antonio Genovesi, born in 1712, at Castiglione near Salerno, became professor of the new chair "of commerce and mechanics," founded at Naples in 1755, by Bartolommeo Intiesi, a wealthy Florentine merchant of that city. Genovesi published his lectures under the title of 'Lezioni di Economia Civile,' in 1768. Genovesi took a middle course between the mercantile system and that of the "Economistes." He reckoned three sources of wealth, agriculture, arts, and commerce. He extols agriculture as an ample and perennial spring of public wealth, but he also appreciates commerce and manufactures as the causes of an increase of production. With regard to commerce, he adopts the restrictive system of the mercantile school as to foreign goods, whilst he agrees with the "Economistes" as to the freedom of trade in corn, and of internal trade in general, as well as with respect to the interest of money. He inculcates the principle that labour constitutes the capital of nations as well as of families. But he did not fall into the vulgar error of considering whole classes of society as unproductive because they are not employed in manual labour, such as men of science, scholars, lawyers, soldiers, magistrates, and others. Genovesi wrote also other treatises on political economy, which he succeeded in rendering popular in his own country.

The other Italian political economists of the 18th century are: 1. Francesco Algarotti of Venice, born in 1712, who wrote 'Saggio sul Commercio,' in which he extols commerce as the source of wealth and power, and he quotes the example of England. He also wrote a few short suggestions on the advantages which might be derived from Africa, in a commercial point of view, by the nations of Europe: 'Sulla Preferenza dell' Africa in confronto dell' Asia e dell' America, rapporto all' Industria e dal Commercio degli Europei.' 2. Antonio Zanon of Udine in the Venetian territory, born in 1696, a merchant by profession, wrote letters on agriculture, commerce, and manufactures, which he encouraged also by his exertions. He was a man of a liberal mind and a true philanthropist. 3. Cesare Beccaria of Milan wrote lectures on political economy, in which he expounded, among other things, the advantages of the division of labour, and he investigated the relations of wages and labour, and the nature of productive capitals. With regard to the corn-trade, he agreed with Carli and Galiani in not advising any general system. He considered large masses of property as more advantageous to a country than small subdivisions. In general, Beccaria may be considered as belonging to the school of the "Economistes." [Beccaria, Cesare Bonesana, in Biog. Div.] 4. Pietro Verri, born at Milan in 1727, the intimate friend of Beccaria, although he differed from him on several points of political economy, wrote 'Memorie sull' Economia Pubblica dello Stato di Milano,' in which he shows the decline of that country during the two centuries of Spanish dominion, and ascribes it to the ignorance of its rulers and the absurdity of the laws. He wrote also 'Riflessioni sulle Leggi Vincolanti, principalmente sul Commercio dei Grani,' in which he advocated the principle of absolute liberty. Lastly, he wrote 'Meditazioni sull' Economia Politica,' which were published in 1771, and have been translated into several languages. It is an elementary but useful book. 5. Ferdinando Paoletti, born in 1717, near Florence, wrote, in 1769, 'Pensieri sopra l'Agricoltura,' and, in 1772, 'Veri Mezzi di rendere felici le Societa,' in which he advocated freedom of trade. 6. Gian Battista Vasco, born at Mondovi in Piedmont, in 1733, wrote 'Saggio Politico sulla Moneta,' 1772, in which he treats of various questions of political economy. He afterwards wrote, in French, 'Mémoire sur les Causes de la Mendicité et sur les Moyens de la supprimer,' which he sent to the Academy of Valence in Dauphiné, in 1788. His other works were 'Sulla Felicita Publica considerata nei Coltivatori di Terre proprie;' and 'L'Usura libera.' 7. Giammaria Ortes, born at Venice in 1713, wrote a work entitled 'Dell' Economia Nazionale,' libri sei, 1774, which however remained unknown except to a few friends of the author, until Custodi inserted it in his great collection of the Italian economists. His views were original, and he belonged to none of the schools already established. He lays it down as a fundamental principle that the capital of a nation is always in proportion to the population, and that the only difference is in its distribution. If a portion of the population becomes richer, it can only be by impoverishing the rest. As a consequence of this principle, he asserts that all endeavours to increase industry with a view to increase the national wealth are futile. But he supports also the principle of freedom of trade between nations, because, he says, every nation has its own capital, which cannot be diminished nor increased by exchange. Ortes wrote also 'Riflessioni sulla Popolazione per rapporto all' Economia Nazionale,' 1790, in which he stated several positions which have been since developed by Malthus, such as that population increases in proportion to the increase of production; that population does not always increase with the increase of marriages, &c. 8. Filippo Briganti, a native of Naples, published, in 1780, 'Esame Economico del Sistema Civile,' in which he refutes the theories of Mably, Rousseau, and Linguet, who asserted that the state of society, and civilisation, commerce, and wealth, were the origin of all the evils with which man is afflicted. 9. Gaetano Filangieri, born at Naples in 1752, is known by his work on legislation, the second volume of which treats of political economy. He belonged to the school of the French economists, but he was not a servile follower of that school. He was a supporter of the freedom of trade; he had no prejudices against luxury, but he advocated direct taxation, or the tax on land, and he maintained that large cities were injurious to the prosperity of a country. [FILANGIERI, in BIOG. DIV.] 10. The Marquis Caraccioli, while he was viceroy of Sicily, wrote 'Riflessioni sull' Economia e l'Estrazione dei Frumenti della Sicilia fatte ad occasione della Carestia del 1784 ed 1785.' The author, being struck with the fact that Sicily, once the granary of Rome, should be so frequently afflicted with scarcity and famine, sought to investigate the causes of this great change. He recommended freedom of internal trade, but with regard to the exportation of corn, he thought it might be suspended at times by an act of government from prudential motives. 11. Saverio Scrofani, on the contrary, in a 'Memoria sulla Libertà del Commercio dei Grani della Sicilia,' published in 1795, advocated an entire and permanent freedom in the corn-trade, quoting the example of Tuscany, where that system had been in practice since 1767, and had been attended with the best results. 12. Maurizio Solera, a native of Piedmont, wrote in French, 'Essai sur les Valeurs,' which he presented in 1786 to King Victor. He proposed an agricultural bank in order to make up for the scarcity of bullion. But his project was not carried into effect. 13. Lodovico Ricci, a native of Modena, was named, by the Duke Ercole III., member of a commission appointed to inquire into the charitable institutions of the town of Modena. Ricci was the reporter of the commission, and his report was published and dedicated to the duke: 'Riforma degl' Instituti Pii della Città di Modena,' 1787. He was one of the first in Italy (Ortes and Genovesi had already expressed opinions similar to his) who censured indiscriminate charity as encouraging idleness and improvidence, and thus creating pauperism. Italy abounded at that time, more perhaps than any country in Europe, with charitable institutions. In Modena, which had in the time of Ricci a population of 40,000 inhabitants, there were 7000 destitute persons. Ricci demonstrated from historical facts that pauperism increases in proportion to the facility of obtaining relief. He censured legacies for portioning poor girls, and other premiums on marriage, and said that the increase of population should only be the result of labour and frugality, by which the means of subsistence are increased. He proposed that charitable institutions should be supported by private charity, and not by the government, which should not do more than establish workhouses to give employment to paupers and vagrants, instruct the poor classes, and endeavour to raise their moral condition. The advice of Ricci was acted upon by the government of Modena. 14. Giuseppe Palmieri, born in 1721, in the province of Lecce, in the kingdom of Naples, filled several offices in the administration of his country, and wrote observations on the tarif and on national wealth: 'Osservazioni sulle Tariffe con applicazione al Regno di Napoli,' and 'Sulla Ricchezza Nazionale.' In speaking of commerce, he says that a full and universal liberty would be the best system, but as this liberty is not admitted by any nation, the nation that should alone put it in practice might find it turn to its disadvantage, and its condition would be that of a lamb among wolves. He therefore advises not the prohibitive but the restrictive system, or in other words, a system of custom-house duties on the principle of reciprocity. 15. Count Mengotti of Feltra, in the Venetian state, wrote, in 1791, a book against the exclusive mercantile system, which he styled 'Il Colbertismo,' from the name of Colbert, the great patroniser of that system. This work was written in reply to a query proposed by the Economical Society of Florence, which was put in the following words: "Whether in a state which, by its locality and the nature of its soil, is susceptible of increase of produce and population, it be most advisable to favour manufactures by certain restrictions on the exportation of the raw materials, or to leave it an entire freedom?" Mengotti recommended perfect freedom of trade, and his book obtained the prize. It is one of the best written works of the Italian political economists. Mengotti, Beccaria, and Galiani are three writers who, by their style, have succeeded in enlivening an abstruse subject and making their dissertations entertaining as well as instructive. Mengotti wrote also a memoir, 'Sul Commercio dei Romani,' which obtained, in 1787, the prize from the Academy of Inscriptions and Belles Lettres of Paris. Mengotti maintained, that until the first Punic war the Romans had no commerce in an extended sense; that from the first Punic war to the battle of Actium their commerce consisted in carrying home the spoils of other nations; that from Augustus to Constantine their trade was mainly passive and ruinous; they produced nothing, and bought foreign luxuries and even the necessaries of life with the money they extorted from the subject provinces, and at last they fell gradually again into poverty and barbarism.

The above are the principal Italian political economists of the 18th century. The complete collection of all the Italian writers on political economy was edited by Custodi, in 50 volumes 8vo. Melzi, the vice-president of the Italian republic, supplied the author with the necessary funds for the undertaking. Custodi was afterwards made by Napoleon counsellor of state of the kingdom of Italy, baron, knight of the iron crown, and secretary of finance.

In England, the science of political economy made a marked progress in the latter part of the 18th century through the exertions of Adam Smith, who is considered as the founder of the modern school. In 1776 Smith published his great work, with the modest title of 'An Enquiry into the Nature and Causes of the Wealth of Nations.' In the first book he treats of the division of labour and its wonderful effects, of the real and nominal price of commodities, the wages of labour, the profits of stock, and the rent of land. Book ii. treats of the nature, accumulation, and employment of stock or capital. Book iii. is in a great measure historical, and treats of the different progress of opulence in different nations. Book iv. is employed in discussing the various systems of political economy. Smith did not follow implicitly either the mercantile system or that of the economists; he showed, in opposition to the latter, that the labour of manufacturers and merchants is productive and is a source of wealth; but he at the same time considered agriculture as the most productive kind of labour, and the home trade as more productive than foreign trade. These positions have been combated by writers who have adopted many of his general views. On the subject of foreign trade, modern writers on political economy are divided, some maintaining that all foreign trade is advantageous to a country precisely in the degree in which it is profitable to those who are engaged in it, and independently of war and peace and other national vicissitudes; whilst others contend that the immediate interest of the trader is not in all cases a criterion of the permanent national interest.

Adam Smith's doctrine of universal free trade has found many opponents, and is in fact still a theory, for it is not in practice in any country, though in our own a much nearer approximation to it is made than in any other. His definition of productive and unproductive labour has been contradicted by Malthus, in his 'Principles of Political Economy,' and in France by Say and others. Smith considered commerce as an exchange between producers of various commodities, but not as a cause of fresh production by stimulating new wants in the producers. His doctrine of the "natural rate of wages" has also been controverted. (McCulloch's "edition" of Smith's 'Wealth of Nations,' with a 'Biography of the Author, and Notes and Supplementary Dissertations,' by the editor.)

In 1798 Malthus published his 'Essay on the Principle of Population,' in which he demonstrated that "an increase in the means of subsistence is the only sure criterion of a real permanent and beneficial increase in the numbers of any people." He stated that the population never falls below the level of subsistence, but that it tends, on the contrary, always to exceed it, and is only kept down by moral or physical checks. A consequence of these positions is, that any artificial stimulus to the increase of population by premiums on marriage, laws against celibacy, &c., is injudicious. These inferences had been anticipated by the Italian political economists Ortes and Ricci.

In France, J. B. Say published, in 1802, 'Traité d'Economie Politique,' in which he expounded the principles of Adam Smith, adding many original and important illustrations, especially on the nature and causes of gluts resulting from over-production, which, he maintained, can only be partial and temporary, and can never occur in every species of commodity at once. Say has written several other works on political economy. Garnier also translated the work of Smith into French.

In 1815 appeared an 'Essay on the Application of Capital to Land,' by Mr. West, Oxford, 1815; and about the same time Malthus published 'An Enquiry into the Nature and Progress of Rent,' a subject which was afterwards investigated and expounded by Mr. Ricardo, in his 'Principles of Political Economy and Taxation,' published in 1817, and which is generally considered as the most important work on political economy since the time of Adam Smith. [RICARDO, in BIOG. DIV.] The writings of James Mill were also valuable contributions to the literature of the science.

Among other contemporary writers on political economy, may be mentioned, in England, John Stuart Mill, J. R. McCulloch, N. W. Senior, Thomas Tooke, G. R. Porter, Lord Brougham, Archbishop Whately, C. Knight, William Ellis, Col. Torrens, and Lord Overstone. Many of these names will be found in their respective places in the BIOG. DIV. In France, Sismondi has written several works on political economy: 'De la Richesse des Nations, ou Nouveaux Principes d'Economie Politique;' and 'Etudes sur l'Economie Politique,' which latter work contains many interesting facts, exhibited and commented upon in the usual attractive if not always strictly logical manner of the author. Ganilh published a general review of the principal systems of political economy: 'Des Systêmes d'Economie Politique, et de la Valeur comparative de leurs Doctrines,' 2 vols. 8vo, 1821, a work well deserving a perusal, being written in a temperate spirit and unassuming tone. Frederick Bastiat, also, by numerous works, contributed largely to the popularising of political economy in France; and he has had many successors.

In Germany, Storch published, in French, 'Cours d'Economie Politique,' 6 vols., Petersburg, 1815, and also 'Betrachtungen über die Natur des Nationaleinkommens,' Halle, 1825. Schmalze wrote 'Staatswirthschaftslehre,' 2 vols., Berlin, 1818; and Jakob, 'Grundsätze der Nationalökonomie,' Halle, 1825.

The Spaniards had two writers on political economy towards the end of the last century, Ulloa and Ustariz. The latter wrote 'Teorica y Practica de Comercio y de Marina,' fol., Madrid, 1791.

Political economy has not been neglected in the United States of North America, but few works, we believe, have yet been produced that have attracted much attention in Europe. Tucker's 'Laws of Wages, Profits, and Rent investigated,' and his 'Theory of Money and Banks investigated,' are valuable contributions to the science.

In Italy, the principal writer of the present century on political economy was Melchiorre Gioia of Piacenza, who died in 1824. Gioia was a jurist, a moralist, and a politician, as well as a political economist, and a notice of his works and a short account of his life are given under his name in the BIOGRAPHICAL DIVISION. Here, however, we shall dwell at more length upon his great work on political economy, 'Nuovo Prospetto delle Scienze Economische,' 6 vols. 4to, Milan, 1815-17. Gioia quotes most of the writers, Italian and foreign, who had preceded him, and endeavours to condense their various systems and opinions into a series of principles with their legitimate deductions. He lays down the following objects of the science:—1. To diminish the labour and the time employed in the production, as well as to diminish the quantity of the raw elements employed; in short, to produce with as little labour, time, and cost as possible. 2. To increase the quantity, perfection, and durability of the things produced. 3. The means of obtaining the above results consist in power, which is increased by capital, machinery, credit, association, distribution of labour, in knowledge of the means to improve, and will or activity, which is strengthened by liberty, security, and enlightened opinion of the people in general. A great part of the work is in a tabular form, with quotations and original remarks. Speaking of the influence of the government on the production, distribution, and consumption of wealth, Gioia notes a number of cases in which that influence may be useful, and a number of others in which it is injurious. Under the first head he reckons the construction of good roads, the distribution of courts of justice in each district, to save time and expense to suitors; the establishment of public libraries, consisting of useful books, of collections of natural history, and of philosophical instruments, botanical gardens, &c.; the foundation of gratuitous elementary schools in every commune, and of schools of arts and trades in every town; freedom of the press; the sending well-informed travellers into foreign countries to examine and report the discoveries and improvements made in each. Among the cases in which the influence of the government is injurious, Gioia reckons—1, too heavy taxation, which, by gradually diminishing the disposable capital, prevents its being employed in making improvements; 2, the grant of public money to monastic establishments; 3, the unequal distribution of public burdens; 4, the payment of the judges by fees on the causes which they decide, which is still the case in several countries of the Continent, instead of a fixed salary sufficient to place them above temptation; 5, the inculcation or toleration of popular superstition, false miracles, and impostors; 6, the tribunal of the Inquisition and other inquisitorial censorships, index of forbidden books, &c. Gioia is an advocate for large masses of property, large manufactories, and great commercial cities. His exposition of the advantages of large farms over small ones induced the government of Piedmont to repeal the decree by which the rice-grounds belonging to the crown or the communes were to be parcelled out into small holdings. Gioia gives the preference to arts over agriculture, and he is the only one among the Italian political economists who has established the principle of the "association of labour" (as in the case of joint-stock companies) as an important source of wealth, and has descanted upon its advantages. Gioia wrote also his 'Filosofia della Statistica,' which may be considered as an appendage to his work on political economy. [GIOIA, in BIOG. DIV.]

The other Italian writers on political economy in the present century are—1. Ressi, who in 1808 published a work 'Dell' Economia della Specie Umána,' 4 vols. 8vo. 2. Carlo Bosellini of Modena, who published, in 1817, 'Nuovo Esame delle Sorgenti della Privata e Pubblica Ricchezza.' 3. Giuseppe Pecchio, who wrote, 1, 'Saggio Storico sull' Amministrazione Finanziera dell' ex-Regno d' Italia, dal 1802 al 1814,' London, 1826, in which he treated of various subjects connected with political economy; 2, 'L'Anno Mille Ottocento Ventisei dell' Inghilterra,' Lugano, 1827, in which he treats of the commercial crisis which took place in England in 1826, and of its causes, effects, and remedies; 3, 'Storia dell' Economia Pubblica in Italia,' Lugano, 1829, a work to which the writer of this article is mainly indebted for his account of the Italian writers on political economy. At the end of the work, Pecchio draws a parallel between the Italian and the English economists.

Few English writers on political economy would however admit his to be an accurate statement of their opinions and of the objects of the science as they conceive them. They would also contend that the objects of the science as conceived by the Italian economists are too numerous and too vague to allow of any scientific treatment, and that subjects are blended together by the Italian writers which are capable of being separated and of being confined within distinct and definite limits. Such an objection to the system of the Italian economists is well founded; and the objects of the English economists may be completely defended if their views are simply limited to investigating the elements on which depend the actual production, distribution, and accumulation of wealth in any given community at any given time. This is a field of inquiry sufficiently extensive, and when it has been adequately examined, and not before, we can pass from the determination of what is to what ought to be any one of those elements on which national wealth depends. It would seem almost superfluous to observe that in determining what are the elements of the actual production of a nation, all the elements must be ascertained: the whole condition of the people must therefore be ascertained,—that is, the whole political system must be examined, in order to ascertain what it is, and the state of all the several classes of the community must be ascertained; every law that interferes with a man's actions must be examined, and every restraint that is laid on the disposal of his property. But such an inquiry would be infinite, and yet such an inquiry is necessary in order to ascertain what *is*, and it is quite a distinct matter from determining what *should* be. It follows from these remarks, that the English writers have conceived the science in a way much more limited, but better defined, than the Italian, and yet that even the English writers very inadequately investigate any one branch of political economy, even as they conceive it. Still their inquiries on any given branch of the subject may terminate in a result approaching to the truth, and such a result may be capable of a practical application.

POLLARDS are trees which have had their tops repeatedly cut off for the sake of the faggot-wood, which is used for burning and heating bakers' ovens. The appearance of an old pollard may, in particular situations, be thought picturesque, but nothing can be more unsightly in a landscape than rows of pollards bordering every inclosure, as seen in some countries. It is only in the case of a few trees of quick growth, such as willows and poplars, that there is a profit in making pollards of them. Where wood is required for fuel, it is better to plant a good coppice interspersed with timber-trees; and if this be done judiciously on good sound land, the quantity taken from the farm for this purpose will be as profitable as if it had been kept in cultivation. Trees are often planted in soils which are not worth cultivating; and hence the profit from a good coppice is usually underrated; but if the damage done to the land by the roots and shade of trees be taken into the account, it will be found that it is more profitable to have the wood growing by itself.

On the margin of low rivers running through marshy grounds, it may be profitable to plant willows, poplars, and other soft-wooded and rapidly-growing trees, in order to lop them at stated intervals. Their timber would be of little value if they were left in their natural state; but being lopped every seventh year, they produce rods and faggots, which are readily disposed of. Hence the common saying that "a willow will buy a horse before an oak will buy the saddle."

To manage pollards advantageously the head of the tree should be cut off at a moderate height while the tree is young, and the shoots which spring from the crown must be frequently cut off before they begin to branch out. Thus a good head is formed, throwing out many shoots, which may then be left to grow till they are of a useful size. The willow takes root so readily, that if a branch twelve or fourteen feet long is put two feet into the ground, it will grow, and form a tree at once, which after a few loppings will become a pollard.

If the appearance of rows of pollards is unsightly, the cutting the side branches of trees in hedgerows, leaving only a little tuft at the top, is much worse. No branch above ten feet from the ground should ever be permitted to be cut by a tenant, nor the top of any tree to be cut off in order to make a pollard of it, and a clause to that effect, with a severe penalty, should be inserted in every lease.

POLLUX. [GEMINI.]

POLYA'NTHES TUBERO'SA, or the Tuberose (a corruption of *Plante Tubéreuse*), is a tuberous-rooted plant highly prized for the delicious fragrance of its flowers, on which account it is cultivated in the warmer parts of both the old and new world. It is stated to be an Indian plant introduced into England in 1620; it had however been cultivated in Europe a century earlier. It is more probably of South American origin; as a wild tuberose, Polyanthes gracilis, has been found in South Brazil, which is probably the origin of the garden plant.

The tuberose is too tender a plant to be cultivated in England in the open air; but in the south of Europe it finds a climate suitable to it; and the Genoese supply the principal part of the European market with tubers for forcing. The latter are imported into this country by the Italian oilmen, who sell them, with orange-trees, Narcissus roots, and similar products of the south.

In selecting tuberoses for planting, the largest tubers should be preferred, as the smaller ones will often not flower. All offsets should be carefully picked off, so as to concentrate the vegetation in a single eye. They should be planted in March or April, in pots, in a sandy loam, and forced in a hotbed, with as much bottom heat as is given to a melon. The eye should be about an inch below the surface of the soil. Very little water should be given till the plants are growing; but when once in a state of vigour, they may be supplied copiously. An abundance of light and air should be given the plants as soon as they begin to grow, and this should be sedulously attended to as long as they remain in the hotbed; it will however soon be necessary, on account of their height, to remove them to the greenhouse, where they must be placed near the glass, and their roots still exposed to a temperature similar to that from which they were taken. As soon as they show their flowers, but not sooner, they may be removed to the sitting-room, when their flowering will be completed.

POLYANTHUS, a garden variety of the oxlip primrose, with brown flowers, is one of those plants which have from time immemorial been favourites in gardens. It was probably obtained by accident, and is now propagated either by seeds or division of its root. Florists require that a good variety of this flower should possess a strong scape, a well-filled truss, a corolla with a short tube, a bright yellow eye, and a deep rich brown crimson limb, bordered with a well-defined yellow edging. They require less careful cultivation than the auricula with which they are nearly allied [Auricula], and principally need shade and a strong rich soil kept somewhat moist. Their beauty however diminishes with their age, so that a renewal of the variety from seed is requisite every few years.

POLYCHROITE. [Safranin.]

POLYCHROMATIC ACID. Synonymous with Aloetic Acid.

POLYCHROME. [Esculin.]

POLYCHROMY, a modern term (from the Greek πολὺς and χρῶμα) used to express the ancient practice of colouring statues and the exteriors of buildings.

Among the earliest civilised nations it was a universal custom to decorate not only their temples and palaces with colours, but the statues with which they were adorned. The Egyptians appear to have covered almost every part of their buildings, and the sculpture on the walls, with brilliant colours and gilding. [Egyptian Architecture.] Upon the relics of Assyrian architecture, and the carved slabs, which have been discovered in such large numbers at Kouyunjik, at Nimroud, and especially those of Khorsabad, traces of colour and gilding were in many instances distinctly visible when first found; and we have evidence in the Scriptures (Ezek. xxiii. 14; Jeremiah xxii. 14; Zephaniah ii. 14, &c.), that the walls and ceilings were adorned with figures portrayed in vermilion and other bright colours. [Nineveh, Architecture of.] So again, the Babylonians, the successors of the ancient Assyrians, whilst imitating the sculpture and architecture of their predecessors, were equally profuse in the application of polychromatic decoration. [Persian Architecture.]

It is, however, the polychromy of the ancient Greeks that has most engaged the attention of artists and archæologists. The sources of information respecting it are the remains of Greek art, and the writings of classic authors. There is scarcely any distinct notice of the system or practice of colouring Architecture in any of the ancient writers. A few remarks occur in Vitruvius and Pausanias, which may be construed into an allusion to it, but they are vague, and the systems which have been laid down by several modern writers rest chiefly upon conjecture. It is more than probable, where the architectural members were subject to so great a variety of forms and proportions, that the decorations in colour, which admit of endless variety, were quite arbitrary. Remains of colour have been found by travellers upon ornamental work in most of the architectural ruins of Greece. Many traces were discovered by Dodwell, Stuart, Chandler, Bröndsted, Semper, and others, upon the principal Athenian monuments: upon the temple of Theseus, the Parthenon, the Propylæa, the Erechtheium, the temple on the Ilissus, the monument of Lysicrates, the outer propylæa of the temple of Ceres at Eleusis, and the greater temple at Rhamnus; also upon the temple of Apollo at Bassæ in Arcadia, the Doric ruins at Corinth, the temple of Athene in Ægina, and by Newton upon the remains of the great mausoleum at Halicarnassus; upon the temples of Selinus in Sicily, and upon the basilica at Pæstum.

As to the extent to which the colouring of the exterior of buildings was carried by the Greeks there is considerable difference of opinion. Some excellent authorities, both English and continental, hold that their buildings were entirely covered with colour; while the majority believe that the balance of evidence indicates that in marble buildings the colouring was confined to the capitals of columns, the mouldings and other ornaments, the friezes, the metopes, and the tympana of the pediments. The exterior of the wall of the cella of the temple of Ægina, and the columns of the Doric temple at Corinth (which, however, were not of marble), they admit were covered with a stucco and coloured red. There is, however, direct evidence that the Greeks carried their colouring much farther, even in marble buildings. Several travellers have found colour on portions of the Theseum which are not merely ornamental. In like manner it appears from the analysis by Mr. Faraday of stucco brought by Mr. Donaldson from Athens, that "the surface of the shafts of the columns of the Theseum and other parts of the edifices from which these coatings were taken were covered with a coloured coating." (Report of Committee of the Royal Institute of British Architects, appointed in 1836 to investigate the evidence bearing on the employment by the Greeks of Colour in Architecture and Sculpture, published in the 'Transactions' of the Institute, vol. i., 1842.) Wax seems to have been present in most, if not all, of the specimens analysed by Mr. Faraday. Mr. Bracebridge, as is stated in the same Report, found in the northern portico of the Erechtheium, which is sheltered from the sea-breeze, clear remains of "colour of various shades" in the upper part of the fluted columns as well as in the capitals. Also in excavating, in 1835–36, at the south-east angle of the Parthenon, according to the same authority, the workmen came, at a depth of 25 feet, upon a place where, as he conjectures, the workmen of the Parthenon threw their refuse materials, and there "were found many pieces of marble, and among these fragments of triglyphs, of fluted columns, and of statues, particularly a female head. These three last-mentioned fragments were painted with the brightest red, blue, and yellow, or rather vermilion, ultra-marine, and straw-colour, which last may have faded in the earth." Mr. Penrose found traces of colour of a peculiar yellow tinge upon some parts of the columns of the Parthenon, especially on those of the west front, but he thinks it was originally most likely only a delicate tint to reduce the high light of the marble. Professor Semper and others have also found traces of colour on the constructive as well as the decorative features of Grecian monuments. The latest testimony is that of Mr. Newton, who found in excavating the ruins of the mausoleum of Halicarnassus "an immense number of pieces of painted stucco from the sides of walls," with, among other things, painted borders of the well-known Greek ante-fixal flowers, in several colours; the colours, from the nature of the soil, being preserved in unusual freshness. ('Parliamentary Papers respecting excavations at Budrum,' 1858, p. 4, and Mr. Newton's Letter in Falkener's 'Dædalus,' 1860.)

In later times amongst the Romans, in the times of Vitruvius and Pliny, the practice seems to have degenerated into a mere taste for gaudy colours, and to have been very general, as we see in the ruins of Pompeii, where, however, occasionally the arabesque decorations upon the walls of the courts in the larger houses are very elegant.

With regard to the system of decorating the mouldings, it appears, from the traces found upon ancient monuments, that they were painted in various ways and in a great variety of colours, whether carved or plain; and a tasteful combination of colours must have greatly heightened the effect of even the richest mouldings. These decorations were not confined to the mouldings of the entablature; the ovolo, echinus, and abacus of the capital, and the toruses of the base, were also coloured. Foliage, ova, and beads were the ordinary decorations; but on the Doric tænia a fret was generally painted, and the cymatia of the pediment-cornices were frequently ornamented with gilded metal-work: the acroteria were also surmounted with gilded figures. Upon the larger mouldings, on which foliage was painted, the outlines of the leaves were engraved in the stone. The mutules, dentils, modillions, and the soffits were also variously coloured; but the Doric guttæ were apparently generally gilded. The faciæ of the architraves, and the coronæ of the cornices, were, at least sometimes, left plain. The Doric architrave was sometimes ornamented with gilded shields, as in the Parthenon at Athens, which were placed immediately beneath the metopes. It appears that all friezes which were decorated with sculpture were coloured, which, if the sculpture itself were uncoloured, would be necessary to give the sculpture a proper relief; for the same reason, the tympana of the pediments would also require colour. In the Doric order, the tympanum would necessarily be of the same colour as the metopes: in the Parthenon they were of a pale blue; and in some of the Sicilian monuments red has been found. The metopes require colour, with or without sculpture, to throw the weight of the pediment upon the triglyphs, its natural supporters, which being left plain united the cornice with the architrave, and gave the whole building an elegant lightness of effect which it otherwise could not have. Sometimes the surfaces of walls, &c., seem to have been ornamented with a diaper or pattern delicately painted.

Polychrome sculpture was quite as general amongst the Greeks as polychrome architecture; it is frequently alluded to by almost all the ancient writers, and many statues of this kind are minutely described by Pausanias. The polylithic and the chryselephantine statues both come under this head. [Sculpture.] The painters of statues appear to have constituted a distinct class of artists: *οἱ ἀνδριάντας γράφοντες*, Plato calls them; and Plutarch speaks of the *Ἀγαλμάτων ἐγκαυσταί*, "encaustic-painters of statues," and the art itself as *ἀγαλμάτων ἔγκαυσις*.

That the statues were sometimes entirely painted even in the best period of Greek art there can be no doubt, both from the references to the practice in ancient authors and from traces of colour on many existing examples, as in the sculpture of the Theseum, and on such fragments as those found among the waste materials of the Parthenon, mentioned above, and the red colour found by Mr. Newton on the nude parts of some of the statues, and the tawny colour on the hind-quarters of the Lion, found by him at Halicarnassus. That it was not the universal—perhaps not even the common—practice to *paint* the marble entirely, is evident from the conversation between Lycinus and Aristratus, in the dialogue of the 'Portraits,' or 'Panthea,' in Lucian ('De Imag.,' 5–8), from which it is plain that the Venus of Cnidos, by Praxiteles, and other celebrated statues, were not painted, though parts may have been painted, and the whole body covered with an encaustic tint or varnish.

This last process, whatever it was, must however have required great artistic skill and taste. Plato ('De Republ.,' iv. 420) observes, in speaking of statue-painters, "It is not by applying a rich or beautiful colour to any particular part, but by giving every part its local colour, that the whole is made beautiful." And Pliny relates that, Praxitiles being asked which of his marble statues he preferred, answered, "'Those which Nicias has had a hand in;' so much did he attribute to his *circumlitio*." There has been much difference of opinion as to what this circumlitio was. To understand it, we must remember that Nicias was subsequently—for it is pretty clear that it must have been when he was a young man that he painted the statues of Praxiteles [Nicias, in Biog. Div.]—one of the most famous encaustic-painters of Greece; that Plutarch expressly calls the statue-painters encaustic-painters; and that wax is shown by modern chemical analysis to have been a constituent of the pigment employed in colouring the ancient marbles; and we shall then, looking at the word itself, probably conclude that it was the application of some encaustic material, which required to be rubbed in with great dexterity and with still greater refinement. In the circumlitio of Nicias, and of the ἀγαλμάτων ἐγκαυσταὶ (the encaustic-painters of statues) generally, the naked form probably received only this delicate tint or varnish, the more positive colouring being applied only to the eyes, eye-brows, and lips, to the hair, the draperies, and the various ornaments of dress; and there can be little doubt that marble statues, especially of females, must have had a very beautiful appearance when carefully coloured in this way.

But whatever reserve there may have been in colouring the finer specimens of Grecian sculpture,—and it is almost certain, from the care shown in the selection of the marble, that the colour was not laid on so thickly as to conceal the material,—it is quite certain, from Pausanias and other contemporary authorities, that the archaic statues which were simply objects of worship were entirely coloured, the flesh as well as the drapery, with the strongest—though, as would seem, with conventional rather than the natural—colours, and frequently indeed clothed as well as coloured. Statues of a higher class as works of art often had the hair gilded, and the ears pierced for pendants, as in the case of the Venus de' Medici; and in many statues glass eyes were inserted, with eyelashes of copper, examples of which are still extant.

So direct and various has been the evidence brought to bear on the question of Greek polychromy, that the fact must be regarded as proved; the extent to which it was carried is however less certain; while the desirableness of reviving the practice may be considered more than doubtful. That attempts, more or less partial, have been made to revive the practice by artists of various countries, it is scarcely necessary to mention. One of the most successful attempts is probably that of Mr. Gibson [GIBSON, JOHN, in BIOG. DIV.]; but the admiration which his Venus has obtained, does not appear to have led many other English sculptors to follow his example.

The architects and sculptors of the middle ages painted their buildings and monuments throughout, and with the strongest and brightest colours; but their system was rude and inartistic, being indeed rather ecclesiastical than æsthetic in purpose. In some recent Gothic buildings, and restorations of ancient ones, both in this country and on the Continent, elaborate and costly, if not altogether satisfactory, efforts have been made to revive mediæval polychromy.

(Kugler, *Ueber die Polychromie der griechischen Architectur und Sculptur und ihre Grenzen*; Semper, *Vorlaüfige Bemerkungen über bemalte Architectur und Plastik bei den Alten*; Quatremère de Quincy, *Le Jupiter Olympien*; Zahn, *Pompeii*; Hittorff, *Architecture Polychrôme chez les Grecs*; Stuart, *Antiquities of Athens*; Penrose, *Principles of Athenian Architecture*; Falkener, *Dædalus*.)

POLYGALA SENEGA, *Medical Properties of.* The rootstock and rootlets of this plant, collected in the southern parts of the United States, are used. The rootlets are most potent. The efficacy is greatly impaired by age, so a fresh supply should be procured every year. Neglect of this point is a frequent source of disappointment in using it. Decoction is an objectionable form, infusion in *cold* water is best.

Senega is a powerful agent in combating the secondary effects of antimonial and other metallic poisoning, such as lead. The bark is of a dirty yellow colour; the odour disagreeable; the taste, at first, mucilaginous, then sweet, then acid, but at last acrid, causing an unpleasant feeling of permanent irritation in the throat. The powder of the root causes sneezing: it contains two sorts of resin, a very bitter principle (polygalin), and the acrid principle (senegin, which, when isolated, is insoluble in water, but perfectly so when in its natural state of combination with the extractive matter of the root), isolusin, and polygalate of iron and potassa, &c. It possesses very manifest stimulating and tonic powers, especially over all secreting organs, whether the skin, mucous membranes, or glands. By its irritating qualities it can act as an emetic, but it is rarely used except in croup. In some forms of indigestion, attended with inadequate secretion of saliva, it is extremely useful, but it is permanently serviceable in the chronic ophthalmia of strumous children, as it promotes increased action of the glands. As a gargle, it is an efficacious remedy against the hoarseness occasioned by common colds.

POLYGALIC ACID. This acid is said to constitute the acrid principle of the bitter milkwort. It is a white amorphous powder, without odour, and of a very irritating acrid taste. It is very slightly soluble in cold water, but tolerably so in hot. Polygalic acid is very imperfectly known, and may be identical with saponic acid. It is composed of:—

Carbon	55·70
Hydrogen	7·53
Oxygen	36·77
	100·00

POLY'GAMY is the name of the custom according to which a man may have more than one lawful wife at a time, which custom prevails in several countries. Polygamy has existed in Asia from time immemorial, under the old religions, and Mohammedanism adopted and confirmed the custom. Montesquieu pretends that polygamy in the East is the consequence of the greater number of female births in that country; but this surmise is by no means proved. Another and a more plausible reason may be found in the premature old age of the female sex in some countries. Niebuhr, in his 'Travels in Arabia,' gives a curious conversation which he had with an Arab on the subject.

The Romans did not practise polygamy, nor did the Greeks. The barbarous nations, on the contrary, that is to say, those who were not Greeks or Romans, practised polygamy, with the exception of the Germans, "who alone," says Tacitus, "among all the barbarians, are content with a single wife." ('German.,' 17.)

In the Scriptures we find instances of polygamy recorded before the flood. (Genesis iv. 19.) It was common in the patriarchal times, and we have the instance of Jacob marrying two sisters. By the law of Moses it appears to have been tolerated. (Exodus xxi. 9, 10, and Deuteronomy xxi. 15.) But in the time of our Saviour, no indication appears of its being common among the Jews. Repudiation, or divorce, however, was frequent, and our Saviour (Matthew xix. 9) reprobates the custom. St. Paul speaks always of marriage in terms implying the union of one man with one woman. In Christian countries, Polygamy has been long since universally forbidden, both by the church and by the civil law, under severe penalties, which in some countries amounted to death. In England, it is an offence punishable with transportation, or imprisonment for two years, for a married man or married woman to marry another person during the lifetime of the first wife or husband.

The Koran allows a man to have four legitimate wives; but it is only the rich who avail themselves of this permission. The Arabs are generally content with one wife.

Polygamy is different from modern concubinage, which is the cohabitation of man and woman unsanctioned by any legal ceremony or legal form.

PO'LYGLOTTS (πολύγλωττα, from πολὺς, much, many, and γλῶττα, a tongue), books in several languages. The application of the word is restricted to the Bible, which being a collection of books written by various persons, at various times, and on various subjects, is called Biblia (books), and a Polyglott Bible is therefore called Biblia Polyglotta.

The idea of a Polyglott Bible seems to have been first conceived in the 3rd century, by Origen, who spent many years of immense labour in forming the Old Testament into such a work. This is commonly called Biblia Hexapla, the Bible in six columns. The six columns consisted of 1, the Hebrew text; 2, the Hebrew in Greek characters; 3, the Greek version of Aquila; 4, the Greek version of Symmachus; 5, the Septuagint; 6, the Greek version of Theodotion. These six columns went through the work; but some portions were in eight columns and others in nine, and with reference to these portions it is called Octapla and Enneapla. Considered apart from the Hebrew, and the Hebrew in Greek characters, it is called Tetrapla, the Bible in four columns. Though two languages only were used in the formation of this work, it might not improperly be called a Polyglott. It is to be lamented that, except in the Septuagint, only a few fragments of Origen's performance have come down to us. These were published by Montfaucon, in two vols. folio, Paris, 1714, under the title 'Hexaplorum Originis quae supersunt.'

Among the moderns, Aldus Manutius first planned a Polyglott in Hebrew, Greek, and Latin; but he never printed more than one sheet, a copy of which, supposed to be the only one in existence, is in the royal library at Paris. Its date is 1501. Since that time various Polyglotts have been published, of which the principal are the following:—

I. The Complutensian Polyglott. This was printed at Complutum, the Latin name of Alcala de Henares in Spain. It was begun in 1502, and finished in 1517, but it was not published before 1522. It was patronised by Cardinal Francis Ximenes [CISNEROS, in BIOG. DIV.], who employed seven learned men competent for the undertaking, and who munificently defrayed the entire expenses of its publication. This noble work was dedicated by its patron to Pope Leo X. It is in six volumes, folio. In the Old Testament each page consists of three columns, the left-hand page presenting the Hebrew, the Vulgate, and the Septuagint, and the right-hand the Septuagint, the Vulgate, and the Hebrew, with Hebrew primitives in the outer margin, and a supralineary Latin interpretation of the Septuagint. At the lower part of the page is a Chaldee paraphrase with a Latin interpretation, in two columns. In the New Testament each page has two columns, consisting of the Greek text and the Latin Vulgate with marginal references. The Greek Testament of this Polyglott is remarkable as being the first complete edition ever printed. Besides a variety of prefatory matter in the first volume, the whole of the sixth volume, with the concluding part of the fifth, consists of several distinct performances, making a large apparatus of elementary biblical literature. Of the Complutensian Polyglott 600 copies only were printed, and one is seldom met with except occasionally in public libraries.

II. The Antwerp Polyglott. This was printed by Christopher Plantin, at Antwerp, 1569-1572, in eight vols. folio. The editor was Arias Montanus, who had about sixty assistants. The work was published under the sanction of Philip II., king of Spain, who is reported to have defrayed its expenses, though some are of opinion that he merely lent the money to Plantin, and demanded its repayment in such a manner as to involve him in very great distress. The whole of the Complutensian Polyglott is comprised in this of Antwerp, besides another Chaldee paraphrase of a part of the Old Testament, a Syriac version of the New Testament, and the Latin translation of Santes Pagninus, altered by the editor, Arias Montanus. The Old Testament is in four columns, two in each page, a Latin interpretation of the Septuagint forming one of the columns, with a Chaldee paraphrase on the lower part of the left-hand page, and a Latin interpretation on that of the right. In the New Testament the versions are similarly arranged, Syriac being in place of the Hebrew, and the Latin of Pagninus answering to the Latin interpretation of the Septuagint. The types are bold and finely formed, and the paper is of a yellowish cast and of excellent quality. The sixth, seventh, and eighth volumes consist of lexicons, grammars, and other aids for understanding the contents of the preceding volumes. Of this Polyglott 500 copies only were printed, and the greater number of these were lost in being conveyed by sea to Spain, so that it is more rare than even its predecessor of Complutum.

III. The Parisian Polyglott. This was printed at Paris, by Antony Vitré, 1628-1645, in 10 vols. large folio. The editor was Guido Michael le Jay, who at this time was a layman, but afterwards became an ecclesiastic. He had several learned associates, and he might have had the patronage of Cardinal Richelieu, but, refusing this favour and venturing to publish the work at his own expense, he brought ruin upon himself. This splendid performance contains all that is in the two preceding Polyglotts, with the addition of an Arabic version of the Old and New Testament, a Syriac version of the former, and the Samaritan Pentateuch. These additions however are made separately, so that, though the Parisian Polyglott contains portions of the Bible in seven languages, its pages do not exhibit at one view more than the Antwerp Polyglott. These ten volumes, in imperial folio, present attractions of no ordinary kind. The paper, though perhaps not so fine as that of the Antwerp Polyglott, is beautiful; the types are large, clear, and elegantly formed; the engraver's art moreover is appropriately displayed in furnishing occasional embellishments; in a word, the Parisian Polyglott is altogether as magnificent a work as can well be conceived.

IV. The London Polyglott. This was edited by the learned Brian Walton, who became afterwards bishop of Chester. It is in six vols., large folio. It was published by subscription, and the volumes came out in the following order:—the first volume in September, 1654; the second in July, 1655; the third in July, 1656; and the last three in 1657. "And thus," says Dr. Twells ('Life of Pocock'), "in about four years was finished the English Polyglott Bible, the glory of that age, and of the English church and nation, a work vastly exceeding all former attempts of that kind, and that came so near perfection as to discourage all future ones." Some portions of this Polyglott are printed in seven languages, all open at one view. No one book is given in nine languages; but nine languages are used in the course of the work, namely, Hebrew, Chaldee, Samaritan, Syriac, Arabic, Persian, Ethiopic, Greek, and Latin. A vast body of introductory matter is in the first volume, and the sixth is made up of various readings, critical remarks, &c. Brian Walton was assisted by a number of men who formed a constellation of oriental and general scholars, such as perhaps have appeared together at no other period during the whole history of our country. One of these men was Dr. Edmund Castell, who published his 'Lexicon Heptaglotton' in 1669, two vols., folio. This is a lexicon of the seven oriental languages occurring in Walton's Polyglott, and it has grammars of all these languages prefixed. It generally accompanies the Polyglott, which can hardly be pronounced complete without it. Walton's work is by no means equal in appearance to the three preceding Polyglotts, but in point of solid usefulness to the biblical scholar it is far beyond any one of them. The eight volumes form an extraordinary collection of aids for studying the original scriptures. As the London Polyglott is frequently found in private libraries, a more minute description of its contents appears to be unnecessary. Its history is recorded at length in Archdeacon Todd's 'Memoirs of the Life and Writings of the Right Rev. Brian Walton, D.D., lord bishop of Chester,' 2 vols. 8vo., London, 1821, a work which comprises also notices of all Walton's coadjutors.

V. Bagster's Polyglott. This work was published by the enterprising bookseller by whose name it is known, in 1 vol. folio, London, 1831. The Old Testament is in eight languages, and the New Testament in nine. Eight languages are exhibited at once upon opening the book. The languages are Hebrew, Greek, English, Latin, German, Italian, French, Spanish, and Syriac, the New Testament being given in the last language as an appendix. To these are added the Samaritan Pentateuch in Hebrew characters; the notes and readings of the Masorites; the chief variations of the Vatican text of the Septuagint (which is followed in this Polyglott), and of the Alexandrian as given by Grabe, Oxford; and of the Greek Testament the whole of the selected various readings given by Griesbach in his own edition of 1805. Prefixed to the work are fifty pages of prolegomena in Latin, by Professor Lee, of Cambridge. The types are small, but clear and elegant, and the paper is of excellent quality. The whole volume presents a very handsome appearance.

On the subject of Polyglott Bibles in general, the reader will be gratified by consulting Horne's 'Introduction;' Butler's 'Horæ Biblicæ;' Clarke's 'Bibliographical Dictionary;' Le Long's 'Bibliotheca Sacra,' improved by Masch. There are many more Polyglotts than these we have mentioned. Among the latest is a 'Biblia Polyglotta,' in four languages—Hebrew, Greek, Latin, and German; it was published during 1850–55, under the editorship of Dr. R. Stier and Dr. Theile. It contains, vol. i., the Pentateuch; vol. ii., the historical books and the Prophets, Daniel excepted; vol. iii., the poetical books, Daniel, and miscellaneous; vol. iv., the New Testament.

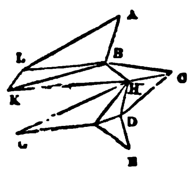
POLYGON and POLYHEDRON. The word polygon means figure of several angles, and polyhedron means solid of several faces: the first is used for a plane bounded by straight lines, the second for a solid bounded by planes. We shall in this article state the general properties of both kinds of figures, reserving the particular consideration of those which have equal sides or equal faces for the articles REGULAR FIGURES, SOLIDS, &c.

The Elements of Euclid confine themselves to convex polygons, and to a limited number of polyhedrons. The most general propositions with respect to polygons as polygons, that is, which are true whatever the number of sides may be, are as follows: they are either in the Elements or immediately deducible from them.

1. The internal angles of a polygon of n sides are together always equal to $n-2$ pairs of right angles. See ROTATION for the full meaning of this proposition.

2. When a figure of an even number of sides is inscribed in a circle, the sum of the first, third, fifth, &c., angles is equal to the sum of the second, fourth, sixth, &c., angles. But when a figure of an even number of sides is *described about* a circle, for angles read sides in the preceding property.

3. Any one side of a polygon is less than the sum of all the others.



The first-mentioned theorem remains true beyond the limits of Euclid's meaning, namely, so long as the figure of n sides can in any way be divided into $n-2$ triangles: that is, in fact, as long as no side of the figure crosses any other side. Thus the adjoining polygon of 10 sides, being divisible into 8 triangles, has the sum of all its angles equal to 16 right angles, four of these angles being each greater than two right angles.

To make a rule which shall connect the angles of any polygon whatsoever, that is, of any figure, however irregular, in which a point returns by a succession of straight lines to the point from whence it set out, would be difficult in the ordinary way of measuring angles. On this subject see SIGN.

A polygon of n sides or edges has one face, and n angular points or corners: that is, the number of faces and corners together exceed the number of edges by 1. On one side of the polygon let another polygon be described: it is then obvious that the two polygons have two corners in common, but only one edge, or else three corners and two edges, &c.; that is, whatever *new* corners are added, one more new edge is added: or, since one face is added, the number of faces and corners is increased by the same as the number of edges. The same may be proved of every new polygon which has one or more sides in common with any of the old ones: and since at the outset the number of corners and faces exceeds the number of edges by 1, and since every alteration adds the same to both sides of this equation, it remains true throughout. Whence the following theorem: let any number of polygons, in the same plane or not, be so connected that each has one side or more in common with one or more of the others: call each polygon one face; each side, to how many polygons soever it may belong, one edge; and each angular point, no matter how many angles may be collected there, one corner: the number of faces and corners will always exceed the number of edges by one.

Let there be a solid polyhedron, and beginning from one given face, annex the others successively: the preceding theorem will remain true, so long as each face which is added adds one or more new edges. But it is obvious that when the polyhedron is completely finished, with the exception of the last face, the completion of the solid, by counting the last face, adds no new edge and no new corner, these having been completely laid down in former faces. Hence,* in every solid polyhedron, the number of faces and corners exceeds the number of edges by *two*.

Again, on a given face of a polyhedron as a base, let a second polyhedron be constructed, and on a given face of that a third, and so on, it being permitted to include several faces from different polyhedrons among the faces of the new one. In the part of each new polyhedron which belongs to the preceding ones, as already shown, the corners and faces exceed the number of edges by one; and the same also in the new portion. But since one new polyhedron is added at every step, it follows that the new faces and corners are the same in number as the new edges and polyhedron. But at the beginning, counting one polyhedron, the faces and corners outnumber the edges and polyhedron by one (since they outnumber the edges by 2); and since both sides of this equation receive the same accession for every new polyhedron, it remains always true: that is, the total number of corners and faces in any system of polyhedrons, each of which has one or more faces in common with others, exceeds the total number of edges and polyhedrons by 1.

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* The present mode of demonstrating this well known theorem was given, for the first time to his knowledge, by the author of this article, in the 'Phil. Mag.'; but he has since found that it is substantially contained (under mathematical symbols which rather conceal its simplicity) in a memoir by M. Cauchy, in the 'Journal de l'Ecole Polytechnique.'

In every face of a polyhedron take any point, which for abbreviation we may call the centre of that face. Join the centre of each face with the centres of the adjoining faces; we have thus a new polyhedron, and the points may be so taken, that those lying in the faces which meet at any corner, shall all be in the same plane. The new polyhedron has obviously as many corners as the old one had faces; and as many faces as the old one has corners: the number of edges being the same in both: and if we call a corner triangular, quadrangular, &c., according as three, four, &c., angles meet there, the new solid has as many triangular, &c., faces, as the old solid has triangular, &c., corners, and *vice versâ*. These polyhedrons may be called conjugate to one another.

Thus there is a triangular tetrahedron (four-faced solid) with four triangular corners: consequently the conjugate solid is another tetrahedron of the same kind. The quadrangular hexahedron (of six four-sided faces) has 8 triangular corners: the conjugate solid has therefore 8 triangular faces, and six quadrangular corners (the triangular octahedron). The pentagonal dodecahedron (having 12 five-sided faces) has 20 triangular corners: the conjugate solid has therefore 20 triangular faces and 12 pentagonal corners (the triangular icosahedron). The solids mentioned in this paragraph are those which may be made of equilateral and equiangular faces. [REGULAR SOLIDS.]

Again, a solid can be formed with 14 quadrangular faces, having 8 triangular corners and 8 quadrangular ones; its conjugate solid has therefore 8 triangular and 8 quadrangular faces, with 14 quadrangular corners; the number of edges in both being 8+8+14−2, or 28.

Let F_3, F_4, F_5, &c., be the number of triangular, quadrangular, pentagonal, &c., faces in a solid, and C_3, C_4, C_5, &c., the number of triangular, quadrangular, pentagonal, &c., corners. Let F, C, E, be the total number of faces, corners, and edges; then we have

$$F = F_3 + F_4 + F_5 + \dots\dots \quad (1)$$
$$C = C_3 + C_4 + C_5 + \dots\dots \quad (2)$$

Again, since $3F_3 + 4F_4 + \dots.$ is the total number of sides of all the faces, before they are joined, and since the junction joins each with another, we have half the preceding for the number of edges, or

$$2E = 3F_3 + 4F_4 + 5F_5 + \dots \quad (3)$$
$$2E = 3C_3 + 4C_4 + 5C_5 + \dots \quad (4)$$

But $F + C = E + 2$, whence we deduce

$$2C = 4 + F_3 + 2F_4 + 3F_5 + \dots \quad (5)$$
$$2F = 4 + C_3 + 2C_4 + 3C_5 + \dots \quad (6)$$

Hence $F_3 + F_5 + \dots.$ and $C_3 + C_5 + \dots.$ must be even numbers; for if these be subtracted from the even numbers $2C$ and $2F$, it will be seen that even numbers are left: or the number of odd-sided figures must be even, and also the number of odd-angled corners. Moreover the number of corners must be made up of (1) a couple; (2) half as many as there are odd-sided faces; (3) 1 for every quadrangle and pentagon, 2 for every hexagon and heptagon, 3 for every octagon and nonagon, &c.; and the same will be true if we write faces for corners, and corners for faces.

Since every face has at least three sides, and every corner at least three angles, $2E$ cannot fall short of $3F$, nor of $3C$. Hence, neither $4E - 6F$, nor $4E - 6C$ can be negative, that is, neither of the following can be negative:

$$3C_3 + 2C_4 + C_5 - 12 - C_7 - 2C_8 - 3C_9 - \dots. \quad (7)$$
$$3F_3 + 2F_4 + F_5 - 12 - F_7 - 2F_8 - 2F_9 - \dots. \quad (8)$$

Hence it appears that there must be either triangular, quadrangular, or pentagonal faces, and either three-angled, four-angled, or five-angled corners. Call these the *essential* faces and corners. Hence the following readily follows:

If the essential faces be all triangles, there must be 4 at least; if all quadrangles, 6 at least; if all pentagons, 12 at least: and the same of the corners. If the non-essential faces be all hexagons, or the non-essential corners six-angled, it would appear[*] that the minimum number of essential faces and corners need not be increased, how many hexagons soever, or six-angled corners, there may be.

We easily show that the formulæ in (7) and (8) are $2F_4 + 4F_5 + 6F_6 + \dots$ and $2C_4 + 4C_5 + 6C_6 + \dots.$ from which, by addition, we find

$$F_3 + C_3 = 8 + F_5 + C_5 + 2(F_6 + C_6) + 3(F_7 + C_7) + \dots.$$

That is, calling both triangles and three-angled corners by the name of *triplets*, quadrangles and four-angled corners by that of *quadruplets*, &c., we have the following theorem:—Space cannot be inclosed without triplets: and the triplets are in number 8, and one for each quintuplet, and two for each sextuplet, and three for each septuplet, &c.

If all the corners be three-angled, we have $2E = 3C$, or (8) vanishes. If then all the faces be of sides not exceeding six, we have

$$3F_3 + 2F_4 + F_5 = 12.$$

Similarly, if all the faces be triangular, and the corners nowhere more than six-angled, we must have

$$3C_3 + 2C_4 + C_5 = 12.$$

Hence it follows that when all the corners are three-angled, and all the faces either pentagons or hexagons, the number of pentagons can be neither more nor less than 12: also that when all the faces are triangles, and all the corners five-angled or six-angled, the number of five-angled corners can be neither more nor less than 12.

If all the corners be four-angled, we have $2E = 4C$, or

$$F_3 = 8 + F_5 + 2F_6 + \dots.$$

whence there must be at least 8 triangles. And similarly, if all the sides be quadrangular, there must be at least 8 three-angled corners.

If all the corners be five-angled, we have $2E = 5C$, or

$$F_3 = 20 + 2F_4 + 5F_5 + 8F_6 + \dots.$$

so that there must be at least 20 triangular faces. Similarly if all the faces be pentagonal, there must be at least 20 three-angled corners.

Some of the most obvious ways in which figures may be put together so as to enclose space are as follows:—

1. Two *n*-sided faces, joined by *n* quadrangles. This includes the prism and truncated pyramid, and also every quadrangular hexahedron.

2. The pyramid, with one *n*-sided face and *n* triangles.

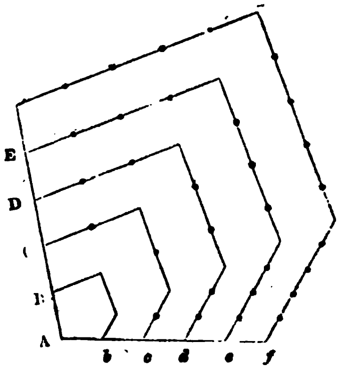
3. The solid with *n* quadrangles, and 2 *n* triangles, the symmetrical case of which is a prism surmounted at each end by a pyramid.

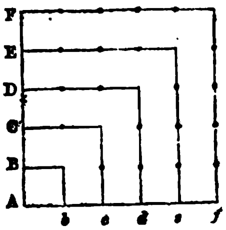
4. Two faces of *n* sides, and *m n* quadrangles, *m* being any whole number.

5. Twelve quadrangles so arranged that four of them are placed corner to corner, the figure being finished by four others on each side. When the quadrangles are all equilateral, this is the common rhombic dodecahedron.

6. The pentagonal dodecahedron, in which there are two pentagons, each of which has another pentagon on every side, the two figures being placed together so that the projecting angles of the one fill up the re-entering angles of the other.

7. The triangular icosahedron, the conjugate solid of the last, which may be thus imagined. Let a pentagonal prism be surmounted at each extremity by a pyramid, and let the sides of the prism which join the angles of the opposite pentagons, and also a diagonal in each quadrangle, be supposed to be formed of extensible and contractible threads. Turn one of the surmounting pyramids partly round: then the sides and diagonals of the five quadrangles will no longer continue in the same plane, but will form ten triangles, which, with the ten belonging to the pyramids, complete the number required.





When the sides of a polygon are given; the polygon itself is not given, unless it be a triangle: thus there is an infinite number of quadrangles which have the same four sides. But it is very remarkable that when a solid is formed of given faces, in a given order of juxtaposition, those faces, if they form a solid at all, can only form one. This is the reason of the stability of solid figures; were it not for this, a box, for example, would require internal cross-pieces to support the sides. This remarkable property is assumed by Euclid as a part of a definition, and that improperly; since it is a new axiom.

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[*] Remember however that this subject is very incompletely known; and though some necessary conditions can be laid down, it has never been found out what conditions are both necessary and sufficient in order that a given number of faces may enclose space.

A proof of the axiom implied in the above was given by M. Cauchy in the article already cited, and will be found in the notes to Legendre's Geometry. It is sufficient, but depends on considerations foreign to the subject as usually considered.

For the remarkable division of equal solids into symmetrically and unsymmetrically equal, see SYMMETRICAL: for the more general view of the nature of polygons, suggested by modern geometry, see TRANSVERSAL: see also TRIANGLE, REGULAR FIGURES and REGULAR SOLIDS, TRIGONOMETRY, &c.

To explain the meaning of the term polygonal number [NUMBERS, APPELLATIONS OF], let us take as an instance the pentagonal number. Take any pentagon B A *b*, and construct a set of pentagons, A C *c*, A D *d*, &c., double, treble, &c., of A B *b* in linear dimension. Divide the sides of each pentagon into parts, each equal to the corresponding side of A B *b*. Then if we begin with A, which is one point, and afterwards take in all the points of the first pentagon, we have 1 + 4, or 5 points. If we now add all the additional points of the second pentagon (including subdivision-points), we have 1 + 4 + 7 or 12 points. Take in the next pentagon, and we have 1 + 4 + 7 + 10, or 22 points. Hence the series 1, 5, 12, 22, &c., is called the series of pentagonal numbers; and a set of numbers is thus pointed out which may be as justly called pentagonal as the set 1, 4, 9, &c., may be called square. It must be supposed that the various sets of polygonal numbers were suggested by the square numbers.

POLYGON OF FORCES. A well-known proposition under this name, attributed to Leibnitz. If any number of forces act upon a point, and we take a polygon, one of whose sides is formed by the line representing one of the forces, and the other sides in succession by lines representing the other forces in magnitude, and parallel to their directions, then the line which completes the polygon will represent the resultant of the whole.

POLYGON, REGULAR. [REGULAR FIGURES; REGULAR SOLIDS.]

POLYGONAL NUMBERS. [NUMBERS, APPELLATIONS OF.]

POLYHEDRON. [POLYGON AND POLYHEDRON.]

POLYMERIDES. Chemical compounds which have the same percentage composition, but a different molecular arrangement. Thus, acetate of methyl and formiate of ethyl are polymerides :—

Acetate of methyl . . . . $\left.\begin{matrix} C_2H_3 \\ C_4H_3O_2 \end{matrix}\right\} O_2 = C_6H_6O_4$

Formiate of ethyl . . . . . $\left.\begin{matrix} C_4H_5 \\ C_2H\ O_2 \end{matrix}\right\} O_2 = C_6H_6O_4$

POLYNOMIAL, an algebraical word meaning an expression which has several terms, being the general term under which are included, binomials, trinomials, quadrinomials, &c., or expressions of two, three, four, &c. terms. The *polynomial theorem* means the theorem by which a polynomial expression is raised to its several powers. For an easy way of doing this, see 'Library of Useful Knowledge,' "Diff. Calc.," pp. 328-337.

POLYPUS is a morbid growth attached to the interior of one or other of the mucous canals, by a more or less narrow pedicle. Polypi occur most frequently near the orifices of external communication of the mucous canals, as in the uterus, the fauces, the larynx, and the nose. A description of those that grow in the last of these situations may serve for all.

Polypi of the nose are of four kinds, which are named respectively, vesicular, gelatinous, fibrous, and malignant. Vesicular polypi are gray or yellowish transparent vesicles, containing a clear watery fluid with a little mucus; they are very soft, easily break down when they are pressed, and are liable to considerable increase of size when the evaporation from them is decreased in damp weather. They appear to consist of enlarged mucous follicles. Gelatinous polypi are more solid growths, consisting of dull white masses attached to the mucous membrane of the nose, and themselves covered by a fine but rather tough membrane. They seem composed of an excessive growth of the mucous membrane infiltrated with fluid, and having a few fibres running through its substance. Fibrous polypi are still more solid growths; they consist of a dense fibrous and vascular tissue, which it is often difficult to cut through, and which is sometimes converted into bone. They are usually intimately connected with the deeper parts of the mucous membrane. Malignant polypi are growths of a cancerous nature from the mucous membrane, which have received the name of polypi rather from having the same situation as the preceding than from their similarity of form. They may assume the characters of simple or schirrhous cancer, but more commonly they have those of the soft or medullary variety [CANCER] which is frequently called fungus hæmatodes.

The common symptoms of all polypi of the nose are that the patient is unable to breathe through the nostril in which they are placed, and has a nasal voice; there is usually a discharge of watery mucus, a loss of smell, and a diminution of the power of taste. If situated far back in the nose, they may cause deafness, or obstruct the swallowing of food. They even render the breathing difficult. The softer kinds seldom produce worse effects than these, for their growth is restrained by the firm tissues of the nostrils; but the two last and firm varieties will continue to increase, expanding the bones and other tissues of the nostrils and face into huge and hideous swellings, and producing death either by their ulceration, or by their pressure on the vessels of the brain, or on the brain itself through the base of the skull.

The most usual situation of polypi is in the upper and back parts of the nostrils; and almost always on the outer wall, the septum being very rarely affected. In their increase they mould themselves to the form of the passages of the nose, and at last protrude either forwards through the anterior openings or backwards into the fauces.

The growth of vesicular polypi is usually connected with a generally disordered state of the health. They seldom require to be removed by operation; the patient should take mild alterative and tonic medicines with purgatives; and lotions containing alum or sulphate of zinc, or some equally powerful astringent, should be frequently injected into the nostrils. When the polypi are thus destroyed, ointment containing nitrate of mercury, or savine powder, or some other stimulant, should be rubbed on the membrane where they were seated. Gelatinous polypi are not usually benefited by the preceding plan of treatment; although after their removal it is very useful to prevent them from growing again. They must be pulled from their attachment by forceps, which should have rough blades, and, if possible, be placed around the pedicle of the growth, and withdrawn with a kind of twisting motion. All the polypi being thus removed, the mucous membrane should have some powerfully astringent lotion or ointment applied to it. The fibrous polypi usually require a more difficult operation for their removal; when they can be withdrawn by the forceps, it is only with much difficulty, from their being seated far back in the nostrils, and with some violence and danger of hemorrhage. In some cases a ligature may be tied round the base of such a polypus, so as to make it slough off; in others they must be cut out with the knife or scissors. The choice of these operations must be made according to the circumstances of each case. After their removal, the same means should be adopted to prevent their return as in the preceding cases. The malignant growths in the nose, like those in other parts of the body, where their early and complete removal cannot certainly be accomplished, had better be treated only by palliative measures.

PO'LYTHEISM (πολὺς, much, many, θεὸς, a god), the doctrine or worship of a plurality of gods. This form of the word is not found in Greek writers. Philo-Judæus conveys the notion by τὸ πολύθεον, and πολύθεος δόξα, and Justin Martyr by πολυθεότης. Philo also speaks of polyarchy (πολυαρχία), with which he contrasts monarchy (μοναρχία), meaning respectively polytheism and the unity of God. St. Athanasius uses πολυθεία as the opposite to μοναρχία.

Polytheism differs from idolatry in this respect :—the former refers to a plurality of gods, without including necessarily the notion of *forms*, real or imaginary; the latter refers either to one god only, under some one visible form, or to any number of gods, under as many visible forms.

No one who takes the Bible for his authority will deny that in the earliest ages of mankind the unity of God was implicitly believed. When the idea of a plurality of gods was first entertained, it is impossible to say. The writings of Moses contain no evidence that men were polytheists before the flood; but it is plain that in the time of Moses (B.C. 1500) polytheism prevailed. It is probable that the Chaldæans, of whom Abraham was one, were addicted to polytheism before his time (B.C. 1900); but it is certain that Abraham was not a polytheist. His contemporaries, Melchizedek, king of Salem, and Abimelech, king of the Philistines, both Canaanites, were worshippers of one God, and the God of Abraham himself. The ancient Persians might have been free from polytheism in Abraham's days; but they became, first, Sabians, or worshippers of the host of heaven, and afterwards Magians, or worshippers of fire. As Magians, they held that there are two principles, one the cause of all good, and the other the cause of all evil; the one they represented by darkness, and the other by light; the former, according to Plutarch ('De Isid. et Osir.,' § 46), was called Oromasdes, and the latter Arimanius. [ARIMANES.] Among the ancient Arabians we find Job and his friends, and Jethro, the contemporary of Moses, worshippers of one God; but yet, in the time of Job, the worship of the heavenly bodies was practised, as is plainly indicated in Job xxxi. 26, 27. The Egyptians, in Abraham's days, seem to have had a religion not different from his; but in the time of Moses, polytheism had become established among them; for many provisions of his law refer to this fact, and are intended especially to guard the Israelites from imitating the polytheism and idolatry of Egypt. Cudworth is of opinion (c. 4, § 18) that polytheism originated in Egypt, but such an assertion is incapable of proof. The Greeks and Romans acknowledged one being, under the names of Zeus (Ζεὺς) and Jupiter, as supreme over all other gods; and they believed further, that this one being was under the absolute power of Fate. Yet these inferior beings were worshipped as gods, and the system was essentially polytheistic.

Cudworth has written at great length to show that the ancient philosophers in general, though they seem to have been polytheists, were not really such, and that they worshipped mentally one Supreme Being under different names. But however this might be, the popular notions were not so refined. Wherever the philosophers have appeared to be polytheists, the people have been polytheists in reality; and, as Philo-Judæus says ('De Ebrietate'), "Polytheism in the minds of the ignorant is atheism."

Wherever the Christian religion has been established, polytheism and its attendant evils have disappeared; but there still remain vast portions of the world in which polytheism prevails; and the miseries are inconceivably great which millions of the human race are still voluntarily inflicting upon themselves with a view to propitiate the favour of imaginary deities.

(Cudworth's *Intellectual System;* Henry More's *Mystery of Godliness;* Shuckford's *Connection of Sacred and Profane History.*)

POMEGRANATE. Under Punica, in the Nat. Hist. Div., a notice has been given of the medicinal properties attributed to the flowers and the bark of the root of the pomegranate, but they have not been much used in European practice. The inspissated juice of the fruit forms one of the most agreeable constituents of the sherbets of the East; and the abundant and pleasant acid of the fruit renders it not only a favourite when eaten, but is held in high estimation as an ingredient in those refreshing and cooling beverages so much needed in hot climates, and to which the professors of the Moslem faith are confined. It is also used to flavour certain cooked viands, much as lemon-juice is employed in Europe. In this country it can only be reared as an exotic, and with little success even then as regards the fruit.

PO'NTIFEX was the name by which the Romans designated the members of the most illustrious of their great colleges of priests, and is supposed to have been derived from the sacrifices having been performed on a bridge connecting the city on both sides of the Tiber. The pontiffs are said to have been instituted by Numa Pompilius for the purpose of taking care that the laws relating to religion should be observed by individuals as well as by the state. Their original number, according to Livy (x. 6), was four, two for each of the tribes of the Ramnes and Tities. Cicero ('De Rep.' ii. 14) says that their number was five, but he includes the Pontifex Maximus, or chief pontiff.

The minor pontiffs were a college of priests of which scarcely anything is known: Cicero mentions three members of it ('Harusp. Resp.' 6). The name of the minor pontiffs was afterwards transferred to, or perhaps assumed by, the secretaries of the other pontiffs (pontifices majores: Liv. xxii. 57; Capitolin., 'Vit. Macrin.,' 7).

When the great state offices had become accessible to the plebeians, they also obtained the privilege of being represented in the college of pontiffs by members of their own order. This change was brought about in 300 B.C. by the Ogulnian law, by which the original number of pontiffs, through the addition of four plebeians, was increased to eight, or, including the chief pontiff, to nine. (Liv. x. 6, 9.) The chief pontiff, however, continued to be taken from the patricians to the year 254 B.C. (Liv. 'Epit.' xviii.) This number remained the same for more than two centuries, until in 81 B.C. the dictator Sulla raised it to fifteen. (Liv. 'Epit.' 89.) J. Cæsar added one more pontiff. (Dion Cass., xlii., p. 236.) In the early ages of the history of Rome the pontiffs were elected by the kings, but after the overthrow of the kingly power the college exercised the right of co-optation (Dionys. Hal., ii. 73; Livy, xl. 42), until 104 B.C., when the right of electing persons to the office of pontiff was partly transferred to the people by the Domitian law; for, according to this law, the co-optation of the college was still necessary as a religious ceremony, after a person had been elected by the people. (Cic., 'in Rull.,' ii. 7.) When Sulla increased the number of pontiffs, he, at the same time, gave back to the college the full right of co-optation; the tribune Labienus, indeed, in 63 B.C., revived the Domitian law, but it was again abolished by Antony. (Dion Cass., xliv., p. 305.) The chief pontiff, who at first seems to have been appointed by the kings, was afterwards elected by the curies in the comitia curiata, and generally taken from the number of the pontiffs themselves, or from those who had held the highest offices of the state. (Liv. xl. 42; comp. with xxv. 5.) The functions of the college of pontiffs were not limited to the service of any particular deity. It had very extensive powers, and not only had the superintendence over all matters of religion, but even those which were in any degree connected with it, such as marriage, adoption by adrogation (Cic., 'Pro. Dom.,' 13), and funeral ceremonies. The pontiffs had a direct judicial power, and might, in some instances, even punish with death. (Cic., 'De Legg.,' ii. 9; comp. with Liv. xxii. 57.) The chief pontiff, whose office, like that of the other pontiffs, was for life, and who was not responsible either to the senate or the people, was supreme judge in all matters relating to, or connected with, religion; and from his sentence an appeal could only be made to the people in cases where a magistrate was fined, or his person seized (Liv. xl. 42); for the few instances of later times, where a tribune interposed and modified the sentence of the chief pontiff, seem to have been anomalies. His powers extended over magistrates as well as private individuals; and the former, if acting contrary to the laws of religion, might be fined (Liv. xxvii. 51; Cic., 'Philip,' xi. 8; Liv. xl. 42), or compelled by the chief pontiff to resign their office. It also formed part of his duties to regulate the calendar, and to interpret the ceremonial laws, for he and his college were in the exclusive possession of the ritual books (commentarii sacrorum or libri pontificales), in which all religious rites were laid down, and which at all times were considered as decisive upon any point which belonged to their jurisdiction; and consequently, they decided what auguries were to be received. The rules and regulations which guided the pontifices formed a large body of law, called 'Jus Pontificium.' (Cic., 'De Or.,' i. 43; iii. 33; 'Pro Dom.,' 13.) Among the external distinctions of the pontiffs, were the toga prætexta, and the tutulus or galerus, a cap of a conical form adorned with an apex. They lived in public buildings on the Via Sacra (Suet., 'Cæs.,' 46), or in the house of Numa (Plin., 'Epist.,' iv. 11). The chief pontiff was not permitted to quit Italy (a rule first violated by P. Licinius Crassus); he was not allowed either to see or to touch a corpse, or even to visit a house in which there was a dead body. After the death of his wife, who, according to the laws, should always be a woman of great moral virtue, he was not permitted to marry again. (Plin., 'Paneg.,' 83.) He also elected the vestal virgins, and superintended their moral conduct. From the time that Augustus assumed the office of chief pontiff, it was held by all his successors down to the time of Gratianus, who disdained this dignity. (Zosim., iv. 36, 9.) The title P.M., or Pon. M., Pontifex Maximus, appears on some of the coins of the Roman emperors. The mode of living of the Roman pontiffs does not seem to have been much more sober or simple than that of some priests of modern times. (Horat., 'Od.,' ii. 14, 26, ff.; Martial, 'Epigr.,' xii. 48, 12; Macrob., 'Sat.,' ii. 9.)

In the Roman Catholic church, the Pope has the title of Sovereign Pontiff. In the Liturgy of that church all prelates are styled Pontiffs. The book of ceremonials for the administration of the sacrament is called the pontifical; and the pontificate is alike the dignity of the pope, and the period during which he occupies the seat. It is observable that the early Christian priestly communities were frequently the founders or guardians of bridges.

PONTOON, or PONTON. This term is employed by the French to signify any barge or flat-bottomed boat; but in this country it is confined to those vessels which are used in the formation of floating-bridges for military purposes.

The conveyance of an army with its artillery and baggage across the rivers which intersect its line of march is one of the most difficult as well as the most important operations in military tactics. The occupation of an advantageous position in a given time, when the army acts offensively, materially influences the success of a campaign; and the favourable moment may be lost, if means should not be at hand to overcome the obstacle presented by a deep and rapid stream. But the failure or insufficiency of such means must be attended with the most fatal consequences to a retreating army, when it is prevented by a river from getting beyond the reach of an enemy; for its safety, in this case, depends upon the power of passing the river without delay, and upon the removal or destruction of the bridge immediately afterwards.

History presents us with innumerable instances, both of the ruin of armies caused by the want of means to make good their passage across rivers, and of the protection which armies have received when rivers have interposed between them and the superior forces of an enemy. To take an example from modern warfare, it may be observed, that during the retreat of Napoleon from Moscow, had it not been for the extraordinary care used by the chief of the French engineers to preserve the materials requisite for the formation of a bridge, the whole of the army must have been captured or destroyed on the banks of the Beresina.

The rapidity of warlike operations seldom allows bridges, at least those of considerable magnitude, to be constructed on piles or piers; and perhaps the only military work of this nature which need be hinted at is that which was formed by Cæsar across the Rhine. [Bridge.]

Bridges consisting of timber platforms supported on floating vessels appear to have been in use in all ages. But those which were thrown by Darius across the Bosphorus, and subsequently over the Danube, and that which was formed by the order of Xerxes over the Hellespont at the time of his unfortunate expedition into Europe, deserve to be considered as the most famous works of that nature which were constructed by the ancients: and Herodotus, who has preserved (lib. iv., 88) the name of the Greek engineer employed on the two first, has also given a full description of the last (vii. 36). He states that 360 vessels, anchored both at the head and stern, were disposed in parallel directions across the strait with their keels in the direction of the current, in order to diminish the strain on their cables; and that parallel to this line, but nearer the Archipelago, was another consisting of 314 vessels, similarly disposed. The vessels were connected together by cables, over which was laid a platform of planks covered with a bed of earth, and there was a rail on each side. Xenophon also relates ('Anabasis,' lib. ii., c. 4) that the Greeks, in their retreat, passed the Tigris by means of a bridge which was supported on thirty-seven vessels. Of such boat-bridges for military purposes the most remarkable, in modern times, is that which was formed, by the engineers of the British army, across the Adour, in the south of France, in 1814. It consisted of twenty-five chasse-marées, varying in burthen from 20 to 40 tons, which were moored at distances of nearly 40 feet from centre to centre. At first, hawsers resting on their decks were strained by capstans and made fast to some heavy guns which were laid behind the retaining walls on the sides of the river, and these ropes carried the planks which formed the roadway; but after a few weeks they were removed, and replaced by timbers, which from their steadiness were found preferable. The breadth of the river at the place where the bridge was formed is 810 feet, and booms were moored across, both above and below the bridge, for its protection.

The precise period at which pontoons, or flat-bottomed vessels, were first employed to support a bridge is unknown. Folard observes, in his observations on the fifth book of Polybius, that for passing rivers the Germans in his time used vessels formed of timber frames covered with leather: he adds that the Dutch troops had pontoons of wood covered with tin, and that the French took some of them at the battle of Fleurus, which was gained, in 1698, by the Maréchal de Luxembourg over the Prince of Waldeck. Mention is frequently made of pontoon-bridges, both in Germany and Italy, in the beginning of the 18th century, particularly during the campaigns of Marlborough; and, from the speed with which they are said to have been executed when required, it is probable that a corps of men was then particularly employed in that branch of service.

The pontoons employed during the war against Napoleon I. differed but little from those mentioned above. They were of metal over a light framework of wood tinned inside; they were from 17 to 21 feet long, from 4 to 5 feet broad, and from 2 feet to 2 feet 3 inches deep. In the formation of the bridge, a rope was tightly stretched across the river; the vessels were then rowed to their places, and each was made fast at one end to the rope; another rope was then stretched across the river, parallel to the former, at the opposite ends of the pontoons, and to this rope those ends were made fast. When a strong current set obliquely across the river, the sides of every two pontoons were sometimes connected together by rope braces stretched diagonally across the intervals, in order that the effect of the current upon each might be counteracted by a like effect on the next; and in very rapid streams anchors were also thrown out from each or from every second or third pontoon, according to circumstances.

Timber-baulks, or joists, were then laid from the shore to the first pontoon, from that to the next, and so on, at intervals from each other depending upon the breadth of the bridge or the weight to be supported. Every two in the direction of the length were attached together by a bolt, which allowed the bridge to yield to the rise or fall of the water. Above these timbers were placed the chesses, or flooring-planks, close together and perpendicular to the length of the bridge; and these were kept down by a riband or a plank, which was fastened over their extremities on each side of the bridge.

General Sir Charles (then Colonel) Pasley, to whom the department of military engineering in the British service is so much indebted for the improvements which he has introduced into every branch of art connected with practical fortification and siege operations, has proposed a description of pontoon. The form of the old pontoons rendering them difficult to manage in the water, and their great weight, when it was necessary to transport them from place to place by land, causing them to be a serious encumbrance to an army on its march, that officer was led to construct the pontoons in the form of canoes, with decks, each end being shaped like the head of a boat, in order that they might be easily moved through the water by rowing, with either end foremost. They are constructed of light timber frames, covered, except the deck, with sheet copper; and each vessel is formed in two equal parts by transverse partitions, so that the demi-pontoons may be separated from each other when the bridge is to be conveyed on carriages by land with the army. When in the water, the parts are connected together by a rope, which passes through two perforations in the keel, near the place of junction, and by a rectangular frame of wood, which is laid along the deck, and attached to it by lashings. Each half-vessel is also divided into two compartments by a partition; and small pumps are provided, by which the pontoon may for a time be kept afloat, should a hole be made in its side by a shot or by any other accident.

Sir James Colleton, some years since, invented pontoons of wood of a cylindrical form, some o fwhich have been occasionally employed in experimental operations; and cylindrical pontoons of tin, which were subsequently invented by the late General Blanchard, were introduced into the service. These last have hemispherical ends, and are divided both longitudinally and transversely into several compartments by partitions of tin, both to increase their strength and to prevent them from sinking in the water in the event of their being accidentally perforated in any part. They possess the advantages of great lightness and buoyancy; but they have not the durability of copper vessels, and they must be very liable to be injured when transported by land, particularly if a march should take place under a hot sun.

In 1836 the comparative merits of General Pasley's and General Blanchard's pontoons were tried upon the Medway, when large bodies of infantry and cavalry, besides three pieces of artillery, were made to pass over the river on bridges supported by vessels of the two kinds. The order of march was purposely such as to subject the bridges to the severest strains; and a superiority of steadiness on this occasion appears to have led to a preference in favour of the pontoons proposed by the last-mentioned officer.

The breadth and depth of one of General Pasley's pontoons are 2 ft. 8 in. The diameter of one of General Blanchard's cylinders is 2 ft. 8 in. The length of the former kind of pontoons is 22 ft.; of the latter, 24 ft. 6 in.

The manner of forming the bridge, with both kinds, is nearly the same. A rectangular frame, whose length is about equal to the breadth of the platform for the intended bridge (12 feet), is laid down longitudinally on the deck of the canoe, or on the surface of the cylinder, and is kept in its place by rope-lashings; on the upper surface of this frame, in the direction of its breadth, are nailed pieces of wood in pairs, at equal intervals; the distance between every two in each pair being little more than equal to the breadth of a baulk, or joist (2½ inches), one extremity of which is to be received between them, and the number of pairs being equal to the number of baulks which are to support the chesses or planks forming the roadway. A raft is formed with two of these pontoons, by placing them parallel to each other, at a distance, from centre to centre, equal to about 12½ feet; the ends of two baulks, or transoms, as they are called, are made to rest upon the frames before mentioned, the distance between them being equal to the intended breadth of the bridge, and they are kept steady by having near each extremity a hole bored through them, into which enters an iron pin fixed vertically for the purpose in the frame: they are also made fast to the pontoons by ropes passing through rings on the decks. Three or more baulks are then laid down parallel to the transoms, with their extremities confined between the cross-pieces nailed to the frames as above said: the chesses are laid close together above them, and their ends are kept down by ribands, which are attached to the transoms by lashings passing over them, and under the latter, at intervals. In those ribands are fixed rowlock pins; and when the bridge is not formed, the ribands being then placed parallel to the lengths of the pontoons, at the sides of the raft, the latter may be moved on the water by the oars.

When the bridge is to be formed, a certain number of such rafts are rowed to their stations in a line across the river, the lengths of the pontoons being parallel to the banks, and there anchored; the distances between the nearest pontoons in two rafts being equal to that between the two pontoons in each raft. Then each raft carrying the materials which are to make a platform over the water between itself and the next, such platform is laid down in a manner similar to that which is employed in laying down the platform of the raft; and from each of the extreme pontoons a like platform is extended to the shore of the river.

When the banks are favourable, the complement of men attached to each raft of two pontoons—namely, one non-commissioned officer and six privates—can dismount two vessels and their stores from the carriages, launch them, and form the raft in a quarter of an hour. All the rafts being put together at the same time, the whole bridge may be formed in another quarter of an hour. After the passage has been effected, the bridge can be dismantled in eight minutes; the rafts can then be taken to pieces, and the vessels and stores re-packed on the carriages in a quarter of an hour.

In order to convey the pontoons with an army, each is placed, with all its accompaniments, on a four-wheeled carriage. General Pasley proposes to use only a cart with two wheels for each pontoon, the latter being separated into two demi-pontoons, which are placed side by side above their stores. The shortness of these carriages enables them to be turned within a smaller space than would be required for a four-wheeled waggon; but the weight on the shaft-horse in hilly countries would be so great that it would be hardly practicable.

The inconvenience attending the transport of pontoons, or the necessity of passing a river when they are not at hand, has induced commanders of armies to have recourse to bridges supported on rafts of timber or on empty casks, which in Europe can always be procured. Each raft may consist of four or more rough trunks of trees lashed together, and may be retained in its place by anchors, or by being made fast to a rope stretched across the river: the baulks and chesses are applied as in a pontoon bridge. Perhaps the greatest raft-bridge ever formed is that which was executed by General Sokolniki over the Niemen at Grodno, in 1792. Trunks of trees from 50 to 60 feet long, and from 20 to 28 inches in diameter, were united by tens, and every ten were bound together at both ends by transverse braces, so as to form a raft, which, as all the large ends of the trees were placed contiguously, resembled the voussoir of a bridge. All the voussoirs, 57 in number, were placed in the river, side by side, in an arc of a circle having its convexity towards the upper part of the river; and a sort of key-voussoir was formed by a vessel 116 feet long and 22 feet wide, which was moored in the river where the current was the most rapid. Baulks and planks were placed, as usual, above the rafts to form the road. The breadth of the river at that place is about 1080 feet. (Berard, 'Equilibre des Voûtes.')

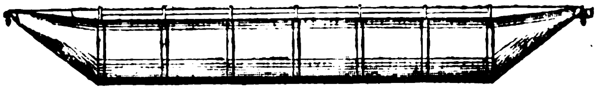
A strong raft-bridge was formed by the Russians and Prussians over the Elbe, near Dresden, in 1813: one course of logs disposed parallelwise to each other formed the bottom of each raft; cross-timbers were laid above these; and over them was a third course of timbers, each placed above the interval between two of those below it. The timbers were well lashed together; a strong cable was stretched across the river on each side of the bridge, which was further retained in its place by anchors, and a road was formed of planks as usual. While the British army was serving in Spain during the Peninsular war, the roofs of buildings were occasionally taken to form rafts: the rafters served as baulks; and, for want of nails, the planks were kept down to the timbers by ribands formed of young trees split in two longitudinally and tied by willow twigs.

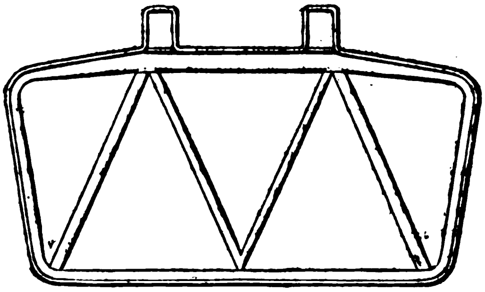
A cask bridge is sometimes formed in the following manner:—A certain number of casks are placed side by side, so as to form a sort of floating pier, having their axes in horizontal positions; the casks are lashed to two gunwale timbers, as they are called, which extend along the upper side of the pier at the extremities of the casks; two of these piers are placed at an interval of about 10 feet from each other, and they are connected together by the baulks which support the platform. As many of these rafts are prepared as may be necessary, they are rowed to their places in the line, and the bridge is formed in the same manner as the pontoon bridge above described.

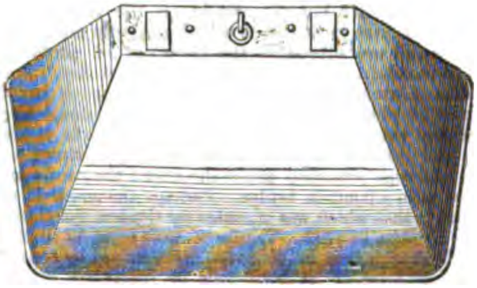
When the formation of a bridge extending over a river from one bank to another becomes impossible, numerous expedients are had recourse to for conveying troops across by means of what are called flying or moving bridges. We learn from Arrian that the army of Alexander passed the Indus by means of boats and rafts of timber, the latter being supported on bags made of skin and inflated with air; and in a similar manner the infantry of Hannibal is said by Livy to have crossed the Rhine. In India, at the present time, the passage of rivers is often effected by means of basket-boats, which are formed of split bamboos and covered with half-dressed hides. Each vessel is said to be capable of containing about 30 men.

In 1811, Captain Squires, of the Engineers, formed a bridge over the Guadiana by fixing trestle-piers in the shallow parts of the river and mooring boats in the middle; but just as the bridge was finished, the river swelled and carried away the trestles. The boats were then converted into flying bridges, to convey over the cavalry and artillery; and a slight narrow bridge was made for the infantry with pontoons and casks, the latter being taken from the neighbouring villages.

Captain Fowke, R.E., has lately invented a pontoon which appears likely to supersede those now in use. It is a *boat* pontoon, the boats consisting of canvas on wooden frames. The accompanying drawings will explain their form. The advantages claimed for them by their inventor are best explained in his own words ('Royal Engineer Corps Papers,' vol. vii.):—


Pontoon expanded.


Section of Pontoon.


Stern of Pontoon.

Pontoon folded.

1. The buoyancy is nearly double.
2. The weight is less than half.
3. The length on the line of march is less than half.
4. The first cost is only two-fifths.
5. The bulk, when packed, is only one-seventh.
6. The height of the roadway above the water is increased.
7. The stability is greater, and the tendency of the bridge to oscillate from side to side is avoided; this motion is caused by the ends of the pontoons being alternately immersed or plunged downwards, and will, *cæteris paribus*, always increase as the vertical section of the pontoon approaches the form of the solid of least resistance; and as a flat surface offers considerably more resistance than one with a circular or curved section, it follows that, independently of all considerations of buoyancy, the canvas pontoon will excel in stability from this cause.
8. The liability to damage from shot is diminished, as a grape shot or musket ball, which would make a serious wound in metal, will merely perforate the canvas with a very small round hole.
9. In the case of a pontoon grounding while under a heavy weight, where the metal one would be put quite hors de combat, the worst that would be likely to happen to a canvas one would be the fracture of a frame or two, which would not occasion a leak, and could easily and quickly be repaired.
10. The pontoon can be bailed out easily, even while in bridge; and this operation is no longer dependent on the small pumps, always so slow in action, and so likely to choke and get out of order.
11. The weight of every individual piece of the bridge is diminished, as well as the number of pieces, and the superstructure is simplified; in forming a bridge, one operation, that of lashing on the saddles (often a difficult one), is entirely avoided.
12. It would appear from the considerations in the last paragraph that each waggon load could be formed into bridge with at least equal celerity as one load of the service equipment, and, if so, there will be a saving of nearly half the time in forming a bridge, eight waggon loads of the canvas pontoon forming as much bridge as fifteen of the service one.
13. The durability is greater: one of the greatest advantages which the canvas pontoon seems to possess over that now in use (as far as can be judged at present) is that while its liability to injury is diminished, in point of durability it appears to be very superior to the latter pontoon, whether on the march, in water, or in store. Jolting on the march, or rolling over uneven ground, or down a stony beach, is almost certain to start one or more joints of the metal pontoon, slightly perhaps, but sufficiently to admit a small quantity of water, so small as to be disregarded; on being brought out of the water the pontoon is then stored with its inside and all its delicate framework quite wet, and the process of corrosion thus commenced, tends still further to weaken the joints and render them even more liable to such accidents; and this accounts for the fact that few, if any, of the present pontoons have ever gone through a summer's practice at Chatham without having to be put at least once into the hands of the tinman for repair. The canvas pontoon, on the contrary, from the elastic and yielding nature of its materials, is less liable to injury on shore; running it on piles or rocks has absolutely no permanent effect on it, for a like reason; and on the march it is enclosed in its own defensive armour of hoops, which effectually protects it from injury. As an example of the durability of such a construction, may be cited the case of the fishing-boats on the west coast of Galway, which are made of canvas stretched over a wooden skeleton, without any external protection, and which stand all weather out at sea for many years. As to durability in store, I have had an opportunity of very carefully examining eight canvas pontoons in store at Chatham; of these one was constructed in the beginning of 1853, two more in the course of the same year, and three in the early part of 1855; and although they have all been out repeatedly, and the latter frequently, I think it will be found that they are not deteriorated in any respect: the oldest of all would be perhaps the better of a coat of boiled oil, but nothing more is necessary for any of them.
14. The canvas pontoon could without much difficulty be made in the field, such materials as hoops of casks, canvas, poles, and oil, being almost always procurable; and one or more extra waggons may be attached to each bridge-train, carrying nine pontoons each, to be available in case of emergency.
15. A *single* pontoon can be used and pulled as a *boat*, for laying out anchors, &c., and as it is stable in the water it may be pulled or poled into its place in the bridge.

Three pontoons, similar to the one described, have been constructed at Chatham, and subjected to some severe tests as to buoyancy; in one instance a heavy 32-pounder was put on a raft of two pontoons and the load was increased by men and sandbags to 95 cwt., with which load it was floated out into the Medway, and it bore it without any apparent strain, and with considerable spare buoyancy. The only point in which these pontoons appeared to be inferior to those in use was in the single one of speed in rowing, the expression in the report being that they seemed to be too light to row well; this appears to me to be a matter of such small consideration that I should not have noticed it but for an idea that seems to prevail that the quicker a pontoon rows the better it will ride at anchor in swift currents or rough water, and which every sailor knows to be fallacious, the fact being that the safe riding depends on the *vertical* angle of the bow, while the speed is mainly influenced by the *horizontal* angle or "lines;" a vessel with a bow that is straight up and down will bury her head much more than one with a "flare bow," that is, one which projects beyond the water-line, even though the former may have the superiority in point of speed.

(For many interesting particulars relating to the passage of rivers in military operations, see Sir Howard Douglas, *On Military Bridges*.)

POOR LAWS. According to Dr. Johnson the term pauper means a poor person; one who receives alms. The term, however, Mr. Glen says, is hardly known to the law, and very rarely occurs in any of the statutes relating to the relief of the poor. The word "poor" by the 4 & 5 Wm. IV. c. 76, s. 109, is to be construed "to include any *pauper* or poor or indigent person applying for or receiving relief from the poor rates in England or Wales, or chargeable thereto;" and in the Lunacy Act, 16 & 17 Vict. c. 97, s. 132, the word pauper "shall mean every person maintained wholly or in part by or chargeable to any parish, union, or county." The latter is the most convenient use of the term, and the word "pauper" will be so understood in this article.

Those who are ordinarily designated paupers are only one class or division among several who are in the condition of poverty. The poor, as distinguished from the paupers, may be distributed into three classes. 1. Persons without capital, who, being capable of labour, and finding employment, are able to obtain the means of subsistence and no more. 2. Mendicants, capable of labouring, but who will not work, and subsist by obtaining contributions from the humane and charitable. 3. Persons destitute through sickness, infirmity, desertion, or any other cause, and relieved by private charity.

The great object of the earlier efforts in pauper legislation was the restraint of vagrancy. The 12 Richard II. c. 7 (1388), prohibits any labourer from quitting his dwelling-place without a testimonial from a justice of the peace, showing reasonable cause for his going, and without such a testimonial any such wanderer might be apprehended and put in the stocks. Impotent persons were to remain in the towns where they were dwelling at the passing of the Act, provided the inhabitants would support them; otherwise they were to go to the places of their birth, to be there supported. By Acts passed in the 11 & 19 of Henry VII. (1495 and 1504) impotent beggars were required to go to the hundred where they had last dwelt for three years, or where they were born, and were forbidden to beg elsewhere. By the Act 22 Henry VIII. c. 12 (1531), justices were directed to assign to impotent poor persons a district within which they might beg, and beyond which they were forbidden to beg, under pain of being imprisoned and kept in the stocks on bread and water. Able-bodied beggars were to be whipped and forced to return to their place of birth, or where they had last lived for three years.

These Acts appear to have had no permanent effect in repressing vagrancy. An Act passed in 1536 (27 Henry VIII. c. 25) is the first by which voluntary charity was converted into compulsory payment. It enacts that the head officers of every parish to which the impotent or able-bodied poor may resort under the provisions of the Act of 1531, shall receive and keep them, so that none shall be compelled to beg openly. The able-bodied were to be kept to constant labour, and every parish making default was to forfeit twenty shillings a month. The money required for the support of the poor was to be collected partly by the head officers of corporate towns and the churchwardens of parishes, and partly was to be derived from collections in the churches, and on various occasions where the clergy had opportunities for exhorting the people to charity. Almsgiving beyond the town or parish was prohibited, on forfeiture of ten times the amount given. A "sturdy beggar" was to be whipped the first time he was detected in begging; to have his right ear cropped for the second offence; and if again guilty of begging, was to be indicted "for wandering, loitering, and idleness," and if convicted was "to suffer execution of death as a felon and an enemy of the commonwealth." The severity of this Act prevented its execution, and it was repealed by 1 Edward VI. c. 3 (1547). Under this statute every able-bodied person who should not apply himself to some honest labour, or offer to serve for even meat and drink, was to be taken for a vagabond, branded on the shoulder, and adjudged a slave for two years to any one who shall demand him, to be fed on bread and water and refuse meat, and made to work by being beaten, chained, or otherwise treated. If he ran away during the two years, he was to be branded on the cheek, and adjudged a slave for life, and if he ran away again, he was to suffer death as a felon. If not demanded as a slave, he was to be kept to hard labour on the highways in chains. The impotent poor were to be passed to their place of birth or settlement, from the hands of one parish constable to those of another. This statute was repealed three years after, and that of 1531 was revived. In 1551 an Act was passed directing that a book should be kept in every parish, containing the names of the householders and of the impotent poor; that collectors of alms should be appointed who should "gently ask every man and woman what they of their charity will give weekly to the relief of the poor." If any one able to give should refuse or discourage others from giving, the ministers and churchwardens were to exhort him, and, failing of success, the bishop was to admonish him on the subject. This Act, and another made to enforce it, which was passed in 1555, were wholly ineffectual, and in 1563 it was re-enacted (5 Eliz. c. 3), with the addition that any person able to contribute and refusing should be cited by the bishop to appear at the next sessions before the justices, where, if he would not be persuaded to give, the justices were to tax him according to their discretion, and on his refusal he was to be committed to jail until the sum taxed should be paid, with all arrears.

The next statute on the subject, which was passed in 1572 (14 Eliz. c. 5), shows how ineffectual the former statutes had been. It enacted that all rogues, vagabonds, and sturdy beggars, including in this description "all persons whole and mighty in body, able to labour, not having land or master, nor using any lawful merchandise, craft, or mystery, and all common labourers, able in body, loitering and refusing to work for such reasonable wages as is commonly given," should "for the first offence be grievously whipped, and burned through the gristle of the right ear with a hot iron of the compass of an inch about;" for the second, should be deemed felons; and for the third, should suffer death as felons, without benefit of clergy. For the relief and sustentation of the aged and impotent poor, the justices of the peace within their several districts were "by their good discretion" to tax and assess all the inhabitants dwelling therein. Any one refusing to contribute was to be imprisoned until he should comply with the assessment. By the statutes 39 of Elizabeth, cc. 3 and 4 (1598), every able-bodied person refusing to work for the ordinary wages was to be "openly whipped until his body be bloody, and forthwith sent, from parish to parish, the most straight way to the parish where he was born, there to put himself to labour as a true subject ought to do."

The next Act on this subject, the 43 Elizabeth, c. 2, has been in operation from the time of its enactment, in 1601, to the present day. An entire change in the mode of administration which had grown up under its provisions was however effected by the Poor-Law Amendment Act (4 & 5 Wm. IV. c. 76), which was passed in 1834. During that long period many abuses crept into the administration of the laws relating to the poor, so that in practice their operation was subversive of the morals of the most numerous class, and injurious to the welfare of the whole country. In its original provisions, the Act of Elizabeth directed the overseers of the poor in every parish to "take order for setting to work the children of all such parents as shall not be thought able to maintain their children," as well as all such persons as, having no means to maintain them, use no ordinary trade to get their living by. For this purpose they were empowered "to raise, weekly or otherwise, by taxation of every inhabitant, parson, vicar, and other, and of every occupier of lands, houses, tithes, mines, &c., such sums of money as they shall require for providing a sufficient stock of flax, hemp, wool, and other ware or stuff, to set the poor on work, and also competent sums for relief of lame, blind, old, and impotent persons, and for putting out children as apprentices." Power was given to justices to send to the house of correction or common jail all persons who would not work. The churchwardens and overseers were further empowered to build poor-houses, at the charge of the parish, for the reception of the impotent poor only. The justices were further empowered to assess all persons being of sufficient ability for the relief and maintenance of their children, grandchildren, and parents. The parish officers were also empowered to bind as apprentices any children who should be chargeable to the parish.

These simple provisions were in course of time greatly perverted, and so many abuses were engrafted upon the statute, that it became an instrument of more general demoralisation than was ever sanctioned by legislative authority. It would greatly exceed any reasonable limits to trace the progress of these abuses. The most injurious practice was that which was established about the year 1795, when, in order to meet the pressure upon the labouring population caused by the high price of provisions, an allowance was made out of the parish fund to every labourer in proportion to the number of his family, and without reference to his being employed or without employment. This allowance fluctuated with the price of flour, and the scale was so adjusted as to return to each family the sum which a given quantity of flour would cost beyond the price in years of ordinary abundance. If things had been left to take their course in England, as they were in Scotland, the labourer's wages would have enabled him to purchase the same, or nearly the same, amount of provisions and other articles of necessary consumption as before the advance, and when the necessity for such a rise in wages had passed away everything would have reverted to its former state. Under the allowance system the labourer was made to receive a part of his earnings in the form of a parish gift, and as the fund out of which it was provided was raised from the contributions of those who did not employ labourers, as well as of those who did, it followed that the labourers were degraded from the condition of honourable independence to that of parish paupers, and that their employers, being able in part to burden others with the payment for their labour, had a direct interest in perpetuating the system. Accordingly it was found that a constant and rapid deterioration took place in the character of the labouring agricultural population, and that they became unable to obtain a rate of wages adequate to their support without parish relief, however moderate might be the prices of the necessaries of life.

There are no accounts of the sums levied year by year in England

and Wales for the relief of the poor before the beginning of the present century. The average expenditure for each of the three years 1783–4 and 5, was 1,912,241*l.*; the earliest account after that date is for 1801, when the expenditure amounted to 4,017,871*l.*, the assessments having been more than doubled in 17 years. It will be seen from the following table how little connection there has been since that time between the sums expended for relief and the price of corn:—

Years.	Sums expended for the Relief of the Poor.	Average Price of Wheat per Quarter.		Years.	Sums expended for the Relief of the Poor.	Average Price of Wheat per Quarter.	
	£	*s.*	*d.*		£	*s.*	*d.*
1813	6,656,106	125	6	1837	4,044,741	52	6
1814	6,294,581	108	9	1838	4,123,604	55	3
1815	5,418,846	73	11	1839	4,406,907	69	4
1816	5,724,839	64	4	1840	4,576,965	68	6
1817	6,910,925	78	10	1841	4,760,929	65	3
1818	7,870,801	94	9	1842	4,911,498	64	0
1819	7,516,704	84	1	1843	5,208,027	54	4
1820	7,330,254	73	0	1844	4,976,093	51	5
1821	6,959,251	65	7	1845	5,039,703	49	2
1822	6,358,704	54	5	1846	4,954,204	53	3
1823	5,772,962	43	3	1847	5,298,787	59	0
1824	5,736,900	51	9	1848	6,180,764	64	6
1825	5,786,989	62	0	1849	5,792,963	49	1
1826	5,928,502	66	6	1850	5,395,022	42	7
1827	6,441,088	56	11	1851	4,962,704	39	11
1828	6,298,000	56	9	1852	4,897,685	39	4
1829	6,332,410	60	5	1853	4,939,064	42	0
1830	6,829,042	62	10	1854	5,282,853	61	7
1831	6,798,889	67	8	1855	5,890,041	70	0
1832	7,036,969	63	4	1856	6,004,244	75	4
1833	6,790,800	57	3	1857	5,898,756	65	3
1834	6,317,255	51	11	1858	5,878,542	53	10
1835	5,526,418	44	2	1859	5,558,689	42	9
1836	4,717,630	39	5				

The extent to which the pauperising of the labourers of England was carried had long been viewed with alarm, and had formed the subject of many parliamentary inquiries, but without producing any substantial amendment, until, in 1832, a commission was appointed by the crown, consisting of the bishops of London and Chester, Mr. Sturges Bourne, Mr. Senior, and five other gentlemen, under whose direction inquiries were carried on throughout England and Wales, and the actual condition of the labouring class in every parish was ascertained, with the view of showing the evils of the existing practice, and of suggesting some remedy. The labour of this inquiry was exceedingly great; but in a comparatively short time a report was presented by the commissioners, which completely explained the operation of the law as administered, with its effects upon different classes, and suggested remedial measures. This report was presented in February, 1834, and was followed by the passing, in August, 1834, of the Poor-Law Amendment Act, in which the principal recommendations of the commissioners were embodied.

The chief provisions of this law are—the establishment of the Poor-Law Commissioners (now the Poor Law Board) to exercise a controlling authority over the administration of relief to the destitute by the local authorities. The administration of relief to the poor is placed under the control of the commissioners, who make rules and regulations for the purpose, which are binding upon all the local bodies. They are empowered to order workhouses to be built, hired, altered, or enlarged, with the consent of the majority of the board of guardians. One very important power given to them was that of uniting several parishes for the purposes of a more effective and economical administration of poor relief. These united parishes, or unions, are managed by boards of guardians annually elected by the ratepayers and owners of property of the various parishes, but the masters of workhouses and other paid officers, though appointed by the guardians, are under the orders of the commissioners, and removable by them. The system of paying wages partly out of poor-rates is discontinued, and except in extraordinary cases, as to which the commissioners are the judges, relief is only to be given to able-bodied persons or to their families within the walls of the workhouse. Another branch of the poor-law, which was materially altered by the Act of 1834, was that relating to illegitimate children. And the law upon this subject has since been further altered by the 7 & 8 Vict. c. 101, and indeed entirely disconnected with the Poor Laws, the mother being now left to enforce her civil remedy against the father of the child.

The number of unions formed, and places in which the rules and regulations of the Poor Law Board are in force, to Lady-day, 1860, is 646, including 14,427 parishes, with a population of 17,670,938 souls.

It will be convenient to state how the law stood previously to the passing of the Poor-Law Amendment Act (4 & 5 Wm. IV. c. 76), and then to notice more particularly some of its leading provisions.

Every indigent person, whether a native or a foreigner, being in any district of England or Wales, in which a fund is raised for the maintenance of the poor, has a right to be supplied with the necessaries of life out of that fund. This right depends on statute, and principally on the 43 Eliz. c. 2, which enacts that the churchwardens of every parish, and four, three, or two substantial householders there, to be nominated yearly under the hands and seals of two or more justices of the peace, shall be called overseers of the poor. [OVERSEERS.] Under this statute overseers could be appointed for parishes only. This proved very insufficient, because many large and populous districts were not situate within any parish, and consequently no overseers whatever could be appointed for them; and also because many parishes themselves were of such magnitude that one set of overseers could not properly attend to all the poor. To supply this defect, the 13 & 14 Car. II. c. 12, authorised the appointment of overseers in any township that was either extra-parochial or was part of a parish so large as to require distinct sets of officers for the management of its poor. The 20 Vict. c. 19 made further provision for the appointment of overseers for extra-parochial places.

It is the duty of these overseers to raise the fund for the relief of the poor of their district. This fund, which is called the poor-rate, they are directed by the statute of Eliz. in parishes, and by the statute of Car. II. in townships, to raise "weekly or otherwise, by taxation of every inhabitant, parson, vicar, and other, and every occupier of lands, houses, tithes impropriate, propriations of tithes, coal-mines or saleable underwoods in the said parish, in such competent sum and sums of money as they shall think fit, &c., according to the ability of the parish."

The rate may be made according to the exigencies of the place, which, whether parish or township, may conveniently in either case be called a parish, for any period not less than a week nor exceeding a year. The rate, which is made in writing, gives the names of the persons rated, a description of the property for which they are rated, and the amount payable by them; it contains also a declaration, signed by the parish officers, that the rate is, to the best of their belief, correct, and that they have used their best endeavours to make it so. The rate so made and signed must be taken to two justices for their assent, which is called the allowance of the rate, and public notice of such allowance must be given on the Sunday following, or the rate will be entirely void.

As the statute expressly mentions both inhabitants and occupiers, inhabitants were held liable to be rated in proportion to their ability within the parish, although they had no property there which was capable of occupation, and occupiers of property therein were held liable although they resided elsewhere. Accordingly both real corporeal property and personal property within the parish may be assessed, as constituting "the ability of the parish;" real corporeal property, as land or houses, may be assessed, wheresoever the occupier resides, and personal property, if the owner is resident within the parish. Incorporeal real property, since it is not the subject of occupation, seems not to be rateable unless incidentally, when, as in the case of the tolls of a canal, it is, as it were, annexed to and enhances the value of corporeal real property, which is the subject of occupation. As it is the occupier and not the owner of real corporeal property who is rated for it, it will be obvious that the term "real property" is not used in the poor-laws according to its strict legal sense, and that the occupier of a house is rated for it, although he has a mere chattel interest in it. The term "personal property" is also used in a restricted sense; it denotes stock in trade, and such things as are not at all of the nature of realty, and excludes chattels real. The assessment is laid in respect of the revenue or annual profit of the property rated, whether real or personal. Such property therefore as is incapable of yielding profit is not rateable. The assessment upon land and houses, &c., is calculated upon an estimate of their net annual value, which is defined to be the rent at which they would let from year to year, free of all tenant's rates and taxes, and tithe commutation rent-charge, if any, and deducting the probable average of annual costs of repairs, insurance, and any other expenses which may be necessary to maintain the premises in a state to command such rent. Personal property was not rated unless it had, as it were, a local existence; and therefore neither stock in the funds nor money was rateable. Furniture also was exempted, because it yielded no profit. In practice the only kind of personal property ever rated, and that in very few places, was stock in trade and ships. The rating of this species of property was attended with many disadvantages. The rate was to be made on the profit, which was defined to be not the whole profit, but the excess after payment of debts. Thus it was nearly impossible to ascertain the rateable amount of such property, and the proprietor might always evade the tax by residing out of the parish. So long however as personal property was rateable by law, the omission of it in the rate was a ground of appeal, because all persons liable are to be rated equally according to their ability. The inconvenience of this state of things induced the legislature to enact by 3 & 4 Vict. c. 89 that no inhabitant should be rated for his stock in trade or other property. The word "inhabitants" may now be considered as struck out of the statute of Elizabeth; nobody will have to contribute henceforward to the poor-rate except in his character of occupier. Personal property therefore is no longer rateable; but nevertheless the exemption depends upon the passing annually of an act of parliament continuing the exemption.

If a parish is unable to furnish a sufficient sum for the maintenance of its poor, any other parish in the same hundred, with the sanction of two justices, or in any other part of the county, with the sanction of the justices at quarter-sessions, may be called upon to assist the less solvent parish. This is called rating parishes in aid.

The overseers are to collect the rate from the persons rated. If a person rated do not pay when called upon, the overseers may obtain a summons, requiring him to show cause why a warrant should not issue to levy the rate by distress and sale of his goods; and, if no sufficient cause is shown, the payment is enforced accordingly. The party so summoned may show for cause that the rate itself is void, or that he is not liable; he may also, with the consent of the overseers, be excused, if it appear that he is unable to pay through poverty. He may also appeal against the rate, and notice of appeal deprives the magistrates of their jurisdiction to distrain until the appeal is decided, unless the objection is solely on the ground of over-charge, in which case the warrant may issue for such a sum as the property was rated at in the last valid rate. The appeal against the rate on the ground of inequality, unfairness, or incorrectness in the valuation of the property rated may be to justices at special sessions, from whose decision a second appeal lies to the general quarter-sessions. The appeal, on the above grounds, may also be taken to the quarter-sessions in the first instance. If the objection be to the principle of the rate itself, or it is intended to dispute the liability of the property to be rated, the appeal lies to the quarter-sessions only. In all these cases of appeal, notice of appeal and of the precise objections to the rate must be given to the parish-officers, and also to any rated inhabitants that may be interested in opposing the appellant, as, for instance, where his ground of complaint is that they have been under-rated.

The overseers who in some parishes acted under the direction of a select vestry, and are assisted by assistant overseers, were to apply the poor-rate to the relief of the poor of their parish. The poor of the parish are, in one sense, all those who happen to be in the parish at the time of their being in distress: for the parish in which they happen to be is bound to afford such paupers immediate, or, as it is called, casual relief. The 13 & 14 Car. II. c. 12, is the foundation of the present law of settlement, which determines the parish to which a pauper belongs, and gives the power of removing him to it. This law is called the law of settlement. The statute enables two justices, upon complaint made by the churchwardens or overseers of the poor of any parish, to any justice of the peace, within forty days after a person coming to settle there, in any tenement under the yearly value of 10*l*., by their warrant to remove such person to the parish where he was "last legally settled, either as a native, householder, sojourner, apprentice, or servant, for the space of forty days at the least." Later statutes have greatly modified the heads of settlement here enumerated, and have added others; they have also made a pauper irremovable, until he has become chargeable to the foreign parish by receiving relief from it, either in person or through the hands of his wife or children.

The following are the settlements that subsisted at the passing of the Poor-Law Amendment Act:—settlement by birth, parentage, marriage, hiring and service, apprenticeship, renting a tenement, estate, office, payment of rates. Settlements may be divided into two general classes; being, first, natural or derivative settlements, as by birth, parentage, or marriage, to the perfection of which residence in the parish is unnecessary; secondly, acquired settlements, including all the remaining settlements above mentioned, and to these residence for forty days in the parish is necessary. The following were the modes of acquiring the various settlements which have been enumerated:—1, settlement by birth.—In order that children may not be separated from their parents, the settlement of the father during his life, and the settlement of the mother after his death, is the settlement of the children. But legitimate children who have no known settlement are settled in the place of their birth; so also are illegitimate children, for they can derive neither settlement nor anything else from their parents. Children, however, during the age of nurture, which continues till they are seven years of age, must not be separated from their parents, and are therefore to be supported in the parish where their parents happen to be, at the expense of the parish of their birth settlement. 2. Settlement by parentage.—The settlement of the father, or, if he have none, the maiden settlement of the mother, is communicated to legitimate unemancipated children. After the father's death their settlement shifts with that of the widow, until she marry again, in which case the settlement of her new husband is not communicated to them. A child is said to be unemancipated so long as he forms part of the parent's family. A child is emancipated when he gains a settlement of his own, or, being of the age of twenty-one, lives apart from and independently of the parent, or contracts some relation inconsistent with his continuing a subordinate member of the parent's family, as by marrying or enlisting as a soldier. Any settlement of the parent acquired after the child's emancipation is not communicated to him. 3. Settlement by marriage.—To prevent the separation of husband and wife, the settlement of the husband is communicated to the wife; she can acquire no settlement during marriage; and, if he have no settlement, she cannot be separated from him by removal to her maiden settlement. 4. Settlement by hiring and service is acquired by a person unmarried, and without unemancipated children, hiring himself for a year into service, abiding for a year in the same service, and residing for forty days in any parish within the year, and with a view to the service. A general hiring, that is, a hiring where nothing is said as to the duration of the contract, is considered a hiring for a year. The service for the year need not be wholly under the hiring for a year, it is sufficient if part of the service be under such hiring; the residue may be either under another hiring, or under no hiring at all. The settlement is gained in the parish where the servant last *completes* the residence of forty days—the forty days need not be consecutive days; if the servant reside thirty-nine days in parish A, then forty days in parish B, and finally another day in A, A, where he last completed a residence of forty days, will be the place of his settlement. All the forty days must be within the compass of a single year, but it is sufficient if the residence for any part of the forty days be under the yearly hiring. 5. Settlement by apprenticeship is gained in the parish where a person bound by deed as an apprentice last completes a residence of forty days in his character of apprentice. No service is required, but the apprentice during the necessary period of residence must be under his master's control. 6. Settlement by renting a tenement is acquired by hiring and actually occupying a tenement at the rent of at least 10*l*. a year, payment of rent to that amount, and residence for forty days in the parish where the tenement is. By actual occupation is meant that no part of the tenement must be underlet. 7. Settlement by estate is gained by the possession of any freehold, copyhold, or leasehold property, and residence for forty days in the parish where the estate lies. If the estate come to a party in any way except by purchase, the value of the estate is immaterial; but a purchased estate confers no settlement if the price given was under 30*l*. But a person residing on his estate, whatever may be its value, is by Magna Charta irremoveable from it while so residing, although he may have gained no settlement in respect of it. 8. Settlement by office is gained by executing any public office in a parish, such as the office of constable, sexton, &c., for a year, and residing there forty days. The office need not be of a parochial nature, but it must be at least an annual office. 9. Settlement by payment of rates.—In order to acquire this settlement a person must have been rated to and have paid the public taxes of a parish, in respect of a tenement hired at a rent of 10*l*. a year, and have paid that amount of rent, and resided forty days in the parish of the tenement. This head of settlement therefore includes all the requisites of settlement by renting a tenement, except the requisite of actual occupation.

All persons whatsoever, whether natural born subjects of England and Wales, Scotchmen, Irishmen, or foreigners, may gain a settlement in this country. A chargeable pauper is to be removed to the place where he last acquired a settlement. It is often very difficult to find out the place of such last settlement; this is so more especially in cases of settlement by hiring and service and apprenticeship, where the residence, being unconnected with anything of a fixed nature, as a tenement or office in any particular parish, may be continually shifting, the settlement consequently shifting with it, until the last day of the service or apprenticeship. Paupers who have no settlement must be maintained by the parish in which they happen to be, as casual poor, unless they were born in Scotland or Ireland, or in the islands of Man, Jersey, or Guernsey, in which case they are to be taken under a pass-warrant of two justices to their own country. When a pauper has become chargeable, and it is sought to remove him, he is taken before two justices, who inquire as to his place of settlement, and, if satisfied, upon his examination and such other evidence as may be laid before them, make an order for his removal thither. The parish to which he is removed may dispute its liability by appeal to the quarter-sessions, when the order of removal will be quashed, unless it appear that the pauper is settled in the appellant parish.

The Poor-Law Amendment Act (4 & 5 Wm. IV., c. 76) has made no change in the law respecting the rateability of property or the mode of collecting the rate. The Act does not apply itself to the rate until collected; it then takes up the rate for the purpose of securing a better distribution of it. To this end the administration of relief to the poor throughout England and Wales is subject to the control of three commissioners. Their powers, and the new agency established for the administration of relief under their direction, have been already described. In parishes or unions where there are guardians, relief is to be given solely by such guardians or by their order, unless in cases of urgent distress. In these cases an overseer is bound to give temporary relief in articles of absolute necessity, but not in money, and if he refuse, he may be required to do so by a magistrate's order, disobedience to which is visited by a penalty of 5*l*. In parishes which have no guardians, the management and relief of the poor is still left to overseers. With the exceptions above stated, the task of relieving the poor is wholly withdrawn from overseers, these officers, from ignorant or corrupt motives, having been generally found incompetent to the discharge of so important a duty. They are still however entrusted with the making and collection of the poor-rate, which they are to pay over to those who have the distribution of it. The general discretionary power which magistrates formerly exercised in ordering relief is also withdrawn. But a single magistrate may still order medical relief, when called for by sudden and dangerous illness; and two magistrates may order relief to adult persons, who from age or infirmity are unable to work, without requiring them to reside in the workhouse. Relief to able-bodied persons cannot be given out of the workhouse, unless with the sanction of the commissioners. In substance, the wants of the poor are as amply supplied as before the Act, but the manner of administering relief is so régulated, by subjecting the applicants for it to the discipline of a workhouse and to other restraints, that the condition of a pauper, living upon the parish fund, is depressed, in point of comfort, below that of the labourer. Thus a ready test is applied to distinguish real and pretended destitution, and a powerful incentive to work is held out to all who can find employment.

The means also of obtaining employment are increased by enlarging the market for the poor man's labour. This is the result of a relaxation in the law of settlement, and particularly of settlement by hiring and service. The old law had been found to obstruct the free circulation of labour by confining the poor to their own parishes. The labourer himself, from attachment to old scenes and associates, was often unwilling to engage himself for a year in a strange parish, lest, by acquiring a settlement there, he should incur, at some future time, a permanent separation from home; the farmer, on the other hand, had an equally strong objection to hire a strange labourer on such terms as to burden his parish with a new settler.

By the Poor-Law Amendment Act, a settlement by hiring and service cannot now be acquired; but the Act does not interfere materially with settlements previously acquired. Settlements by office and by apprenticeship in the sea service or to a fisherman can no longer be acquired. Settlement by renting a tenement is clogged with the additional qualification that the occupier must have been assessed to the poor-rate, and paid the same for one year. Settlement by estate, like any other settlement, when once gained, used to endure till it was superseded by some new settlement; but now it is converted to a temporary settlement, and to be retained so long only as the proprietor shall live within ten miles of the estate. Settlements by marriage and by payment of rates are untouched. Settlement by parentage and settlement by birth are both affected to this extent, that illegitimate children born after the passing of the Act are to follow the settlement of the mother until the age of sixteen, or until they acquire a settlement in their own right; but they revert to their birth settlement after sixteen, unless they shall have acquired another in their own right. The effect of this change in the law is that an unmarried woman, whose pregnancy in itself made her chargeable, is no longer hunted from the parish in which she happened to be, in order that the parish may not, by the birth of the child therein, be permanently charged with its maintenance. The old law of settlement was full of legal difficulties and refinements, and the effect of the change in the law has been to relieve parishes from much litigation.

As already mentioned, a great change also has been introduced in the general laws of bastardy. Formerly the putative father was liable for the support of a bastard, on the unsupported oath of the mother that he was the father of it. Before the birth of the child, he might be called upon to give security to provide for the child, and, if unable to give such security, might be committed to prison; and, after its birth, an order of filiation might be made upon him by two justices out of sessions. By the new Act neither the mother nor the putative father of a bastard can be punished, as was formerly the case. Female incontinence is checked by making the mother liable to maintain her child in the first instance; and, as already observed, she is left to seek her own remedy against the father of her child, without the intervention of the poor-law authorities.

Any person who marries a woman having children, whether legitimate or illegitimate, is made liable to maintain them until they attain the age of sixteen, or until the death of the mother.

(Bl.'s *Comm.*, 359; Nolan's *Poor Laws*; Glen's *Poor-Law Statutes and Poor-Law Board Orders*.)

POOR LAWS, SCOTLAND. The foundation of the Old Poor Law of Scotland was the Act of Parliament 1579, c. 74, which in so many respects resembled the celebrated English statute of the 14th of Elizabeth, passed a few years earlier, as to have been considered a mere adaptation from it. The Scotch Act, however, fell short of the English in the one important particular of not providing for the care of the able-bodied. By this old Act, a settlement was acquired by birth, and once so established could not be changed unless by a seven years' industrial residence in another parish. By the Act of 1672, c. 18, this period was shortened to three years. The method of administering the law, which arose partly out of the terms of the old Acts, partly out of custom, and partly from the directions given to these sanctions by the judgments of the courts, was as follows:—In the rural parishes, the "kirk sessions," or lowest ecclesiastical judicatories, consisting of the parish clergyman and certain elders, shared the management with the "heritors," or rated landed proprietors; but it became customary for the latter body to interest themselves solely in the voting and levying of the rate, leaving its distribution and the management of the poor to the former. In those municipal corporations holding rank as royal burghs, the assessment and management lay with the corporate authorities. The funds for the relief of the poor were of two kinds: the collections at church doors, along with certain fees and eleemosynary bequests, constituted the one department; and rates assessed on the parish, or a substitute voluntarily paid instead of an assessment, the other. Of the sums collected at the church doors, only a half went to the regular relief of those legally entitled to relief; the other became a fund for general charitable purposes at the command of the kirk session. In many cases there was no assessment, and the regular practice came to be, that if the miscellaneous sources were insufficient for the relief of the poor, the heritors and session in a country parish, or the magistrates in a town parish, might levy a rate. It became a common practice for the parties chiefly interested to agree to a "voluntary assessment," for the purpose of postponing the imposition of a fixed legal rate. When an assessment was imposed, it became a rule that one half of it should be levied on the proprietors of land, in respect of their land; the other on householders, in respect of their "means and substance," or their incomes so far as not derived from land. The adjustment of the rating was the ground of much dispute, and different parishes followed very distinct methods in practice.

For a considerable period the Scottish system was very favourably received by political economists, who saw the country in a comparatively sound moral condition, with a parsimonious poor law, while the lavish system of England seemed to promote profligacy and idleness. But from the time when these doctrines were first promulgated to the completion of the great change of the English poor law, a vast internal alteration had taken place in the social economy of Scotland. The comparative low rate of wages, attracting manufacturing capital from England, had caused a more than average migration of the rural labourers to the manufacturing districts, and a peculiarly rapid increase of the city population. It was found that with these complicated materials, the simple parochial system adapted to a state of society where each man watched over the interests and the conduct of his neighbour, was incapable of grappling. It was found that even for poor country districts the system was unsuitable, because, though still far behind the English system in profusion, the administrators were compelled by the voice of public opinion to become more liberal in their dispensations, while the managers of the country parishes not subject to the same influence kept down the allowances, and thus gave the poor an inducement to endeavour to obtain a settlement by three years' industrial residence in the cities. Dr. Chalmers was the great champion of the old system. With the assistance of some enthusiastic followers, he organised the administration of a parish in the poorer parts of Glasgow, as a demonstration of the efficiency of which the system was capable. It was a very pleasing picture, but the public soon felt that the success with which one energetic individual and his enthusiastic followers might voluntarily perform the duties generally exacted by legal compulsion, was no sufficient ground for believing that the rest of the community can be at all times and in all places depended upon for the performance of onerous public services without the coercion of law.

The public were first awakened to the imperfections of the Scottish Poor Law by Dr. W. P. Alison, a physician in Edinburgh, and professor of the practice of medicine in the university. Having frequently administered professional services to the poorer classes, he showed from his own experience that the utter inadequacy of the provision afforded to those who, by inability to work, or bad seasons, or revulsions in trade, were reduced to want, was an extensive cause of disease, vice, and misery. The city population speedily answered to this appeal, and associations were formed, and inquiries made in various directions. It was shown that the amount expended on the relief of the poor in Scotland amounted to little more than a sixth part of the sum distributed throughout an equal population in England by the economised poor law. In England, the expense of supporting the poor amounted to 6*s.* 10¾*d.* per head of the population; in Scotland, to 1*s.* 2¼*d.* In some of the Highland parishes, whence the most destitute objects emigrated over the rest of the country, the allowances were ludicrously small; and a report made to the General Assembly of the Church of Scotland in 1839, enumerated instances where sums averaging from 8*s.* to 1*s.* yearly were solemnly awarded to destitute people, as the provision which the Poor Law made for their wants. In the meantime the discussion of these matters had a tendency gradually to increase the amount of the provision for the poor. The practice of assessments made considerable progress, and a return to parliament in 1843 shows that between 1836 and 1841 the sums raised by assessment had increased from 89,101*l.* to 128,858*l.*; while the sums raised by voluntary assessment had risen from 15,829*l.* to 22,385*l.* A commission was at last appointed to inquire into the whole state of the subject; and after hearing much evidence, they presented a report, accompanied by a voluminous appendix, in 1843. The amendments proposed in this report were supposed to be of a somewhat narrow nature; the country expressed dissatisfaction with them; and in 1845 a measure was passed embodying alterations considerably more extensive.

By this Act, 8 & 9 Vict., c. 83, a board of supervision is appointed, consisting of persons connected with the municipal bodies and the administration of justice in Scotland, with one salaried member, who gives constant personal attendance. The office of the board is in Edinburgh. This board is endowed with ample means for ascertaining, in all parts of the country, the condition of the poor, and the method in which the system of relief is administered. The board has, however, no directory or prohibitory control over the proceedings of the local boards. These bodies are, however, re-organised by the Act. In the rural parishes where there is an assessment, the local board is to consist of landowners to the extent of 20*l.* annual value, the kirk session, and certain elected representatives of the ratepayers, according to the number fixed by the board of supervision. In city parishes, the boards are each to consist of four persons named by the magistrates, deputies not exceeding four from each kirk session in the city, and certain elected persons according to a number and qualification fixed by the board of supervision. In parishes where there is no assessment, the management is to continue under the old system. There is thus in this Act no machinery for levying or exacting a rate for the poor, unless in those parishes where the persons more immediately concerned agree to such a measure. It is held, however, that the facilities which the statute gives the poor for exacting from the respective parochial authorities the relief to which they are entitled, will render it necessary to put more extensive funds at the disposal of the distributors of relief, and this can only be accomplished through the system of assessment. When persons apply for relief, it is provided that, though they have no settlement, if the claim would be just in the case of their having one in the parish where it is made, subsistence must be afforded them till it is determined what parish is liable. When relief is refused, the applicant may apply to the sheriff, who may grant an order for temporary relief, and then hear parties, and decide whether the applicant is or is not entitled to relief. In this form, however, neither the sheriff nor any other judge can decide on the *adequacy* of relief. The initial step to any judicial appeal against the amount of the relief afforded, is by an application to the board of supervision; and on that body reporting its concurrence, the applicant is placed on the poor-roll of the court of session, where he has the privilege of the question being discussed gratis. By this Act, provision is made for medical attendance and medicines, being part of the system of pauper relief, and for the education of pauper children. It is provided, that for the purposes of the Act, parishes may be united into "combinations." By a special clause, nothing in the Act is to be construed as entitling the able-bodied to relief, and their claim is thus left in the state of doubt in which it stood before the passing of the Act. Men deserting their wives and children are made liable to punishment as vagrants, a provision which it is hoped may afford a remedy to a defect which has long characterised the law of Scotland—the absence of any means by which deserted wives can make effectual claim on their husbands for sustenance to themselves and their children, without a regular action in the court of session. By the new Act, a new and more specific mode of apportioning the assessment between landed and other property has been attempted to be established; but this provision is already a fruitful source of dispute and litigation. The time necessary to acquire an industrial settlement is increased from three to five years.

POPE (*Papa*, in Latin) is the title assumed by the bishop of Rome as head of the Roman Catholic Church. The word papa, or papas, meaning "father," is used by the Greeks to denote a presbyter. In the early ages of the church it was given to the bishops in general. (Ducange, 'Glossarium;' Moreri, 'Dictionnaire Historique.') Gregory VII., in a council held at Rome, A.D. 1076, decreed that the title Papa should be given only to the bishop of Rome, as a mark of superior respect.

There are three offices or dignities united in the person of the Roman pontiff. He is—1, the primate or head of the Roman Catholic world; 2, he is bishop of Rome and metropolitan of its province; 3, he is the temporal sovereign of the Papal State. His authority and the manner of his administration in the last-mentioned capacity are described under PAPAL STATES in the GEOG. DIV. We may, however, here add, that in 1860 a very material alteration has taken place in the dominions of the Pope. The far greater part of the territories there mentioned as owning his sovereignty, have transferred their allegiance to Victor Emmanuel of Sardinia, and the power of the Pope is now nearly circumscribed within the Legation of Rome, and the Delegations of Ancona, Viterbo, Orvieto, and Civita Vecchia, and even there it is in effect only maintained by the presence of French troops.

Considered as pontiff and primate of the Roman Catholic church, the pope has a very extensive spiritual authority over the members, both clerical and lay, of that communion. The limits of this authority are however variously defined even by Roman Catholic theologians. We cannot do better than quote on this subject the definition given in a work of considerable repute and written with great discrimination, which is entitled 'Bibliothèque Sacrée, ou Dictionnaire Universel, Historique, Dogmatique, Canonique, Géographique, et Chronologique des Sciences Ecclésiastiques, par les Révérends Pères Richard et Giraud, Dominicains; réimprimé avec additions et corrections par une Société d'Ecclesiastiques,' 20 vols. 8vo, Paris, 1822. Under the head 'Pape,' section iii., 'De la Puissance et Authorité du Pape,' we read as follows:—1. "All Catholics acknowledge that the pope holds by divine right a primacy of honour, of precedence, and of authority and canonical jurisdiction in the whole church, because he is the successor of St. Peter, to whom Jesus Christ granted those privileges. (Matthew x. 2, and xvi. 17-19.) But is the pope infallible in his decisions concerning law or discipline? Is he above the general council? Has he any power, direct or indirect, over sovereigns and kingdoms? Divines are very much divided in opinion upon these questions."

2. "We may consider the pope either as a private and individual doctor of the law, or as the sovereign pontiff speaking 'ex cathedrâ' in his quality of head of the universal church, to which church he proposes something to be believed as an article of divine faith, under pain of heresy, and this he does after having prayed, having consulted the sacred college of cardinals, and employed the other customary means in order to ascertain the truth. Now the French theologians in general, agreeably to the fourth proposition of the Gallican church, maintain, that even in this case, when he speaks 'ex cathedrâ,' the pope is not infallible, and that his decisions become infallible only after they have been accepted by the church, either in council assembled or dispersed in its various congregations throughout the world. The Italian divines on the contrary, commonly assert that the pope is infallible when he speaks 'ex cathedrâ,' independently of the consent of the church. They ground their assertion on the passage in St. Matthew, 'Tu es Petrus,' &c. 'How,' say they, 'can the church be infallible, if the foundation upon which it is built be not infallible? Does the church rest upon Peter, or Peter upon the church?' To this their opponents reply—1, that the rock upon which the church is built means faith, and not the person of Peter; 2, that the promise of infallibility was made to the whole church, and not to Peter individually; 3, that all the passages which are quoted from the Scriptures or the fathers in favour of the infallibility of the pope apply not to the individual who is seated on the chair of St. Peter, but to the chair itself, to the see of Rome, the Roman church, the whole succession of the Roman pontiffs, the universal church in short." The writer of the 'Bibliothèque Sacrée' winds up these conflicting statements by saying, "This question is not one of faith." To this remark however some will object, that the question is considered as one of faith at Rome, for as the Roman (or, as the French call them, the ultramontane) canonists assert the infallibility of the pope by divine right, it follows that they consider the belief in that infallibility, and in all the decisions emanating from it, as matters of faith; and as long as this controversy remains unsettled, a door is always open to schism, as it happened in the council of Basel, and the alleged unity of the Roman Catholic church is only nominal and precarious.

3. "The same theologians who assert the infallibility of the pope, assert also his superiority above the general councils, and that he has the right of dissolving them, transferring them to a different place, of approving or condemning, reforming or abrogating their decisions. Those divines, on the contrary, who maintain that the pope is not infallible, maintain also that he is subject to the general councils both as to faith and discipline. This is the opinion of the French clergy, embodied in the second of the four propositions of the Gallican church, promulgated in 1682, which 'approves the decision of the council of Constance, declaring the councils general to be superior to the pope in spiritual matters.' The assertors of this proposition say that 'the pope is the head of the faithful nearly in the same manner as the general of a monastic order is the head of all the members of that order, to whom however he is subject when they are assembled in a general chapter.' It may be observed here, that besides the council of Constance, which decided this question of the superiority of the general councils over the pope, there is the council of Basel, which asserted the same principle, and that the council of Basel is reckoned by the French theologians among the legitimate councils of the church, but is not so reckoned by the canonists of Rome."

4. "There are some writers who pretend that the pope has by divine right a direct power, both spiritual and temporal, over the whole world. Others maintain that he has at least an indirect power in temporal matters, inasmuch as he can dispose of kingdoms and crowns, and transfer them from one prince to another whenever that is required for the welfare of souls. Lastly, other divines are of opinion that neither the pope nor the church has any power, direct or indirect, in the temporal matters of kingdoms and states, that they cannot in any case depose kings, nor release their subjects from their oath of allegiance. In support of their argument, these divines show that Jesus Christ made open profession of poverty, that he solemnly declared that his kingdom was not of this world, and they allege other passages as equally decisive; and they say that the Saviour bequeathed to the church a purely spiritual authority, to be exercised in preaching, baptising, instructing, and loosening or binding sinners. The early fathers have said that the church has only the spiritual sword to keep its children within the path of duty. The most celebrated universities of Germany, France, and Spain have confirmed this opinion, which is that of the Gallican church and of Bossuet himself. The contrary opinion, namely, that the popes have a temporal jurisdiction over kings and principalities, is not of older date than the time of Gregory VII."

Such are the statements of orthodox Roman Catholics in a work which condemns all heretics and Jansenism: for the Jansenists assert that the pope has no authority over the bishops, but only a superiority of rank; that all the bishops are vicars of Christ, and that the pope is the first among them, and that his jurisdiction is not to confer episcopacy, but only to watch over the conduct of the other bishops, &c. These opinions of the Jansenists are found, among other works, in the 'Acts of the Synod of Pistoia held by De Ricci' ('Atti e Decreti del Concilio Diocesano di Pistoia dell' anno 1786'), which were condemned by Pope Pius VI. As for the Protestant and Reformed churches, they do not acknowledge any authority or jurisdiction in the pope, except over his own diocese as bishop of Rome, or at most over the other dioceses of the province of Rome as metropolitan. The Greek, Armenian, Jacobite, and Nestorian churches likewise disclaim his authority. Several Roman Catholic writers have endeavoured to trace the growth of the supremacy of the Roman see over the churches of the West, which supremacy they assert was once limited to the provinces which constituted, under the Christian emperors, successors of Constantine, the vicariate of Rome, namely, Etruria, the March of Ancona, Valeria, Apulia, Calabria, Lucania, the Abruzzi, Sicily, Sardinia, and Corsica. These provinces were under the lay jurisdiction of an imperial vicar. The rest of Italy, with Rhætia, constituted the vicariate of Italy, of which Milan was the capital. Both vicariates were subject to the prefect of Italy, who had also under his authority the provinces of Africa and Illyria. The provinces which formed part of the vicariate of Rome were called "suburbicariæ," and their diocesans acknowledged the bishop of Rome as their metropolitan. Such is the opinion of Father Sirmond, and of Du Pin, in his 'De antiquâ Ecclesiæ Disciplinâ,' and of Giannone, in his 'Storia civile del Regno di Napoli.' They contend that until the reign of Valentinian III. the metropolitan authority of the bishop of Rome did not extend beyond the suburbicarian provinces. Allatius, Baronius, Maimbourg, and others, on the contrary, contend that the bishop of Rome was by right the metropolitan of the whole West, if not of the whole Roman empire. Gregory I. (the Great), however, disclaimed the title of Œcumenic or universal bishop, and in token of humility assumed that of "Servus Servorum Domini," the "Servant of the Servants of the Lord," which his successors have continued to place at the head of their briefs and decretals.

In his quality of bishop of Rome, the pope delegates his authority as ordinary to a prelate called Vice-Gerente, who is generally a bishop *in partibus*. In his quality of metropolitan of the province of Rome, he has under him the bishops called Suburbicarii of Ostia and Velletri, of Porto and Santa Rufina, of Sabina, of Frascati, of Albano, and of Palestrina. As primate of the Roman Catholic church, he has under him all the cardinals, archbishops, and bishops of the Roman Catholic states; those placed in states professing Reformed doctrines, and those *in partibus*, or having episcopal titles with a nominal see. The total number of people who profess the Roman Catholic religion in Europe is roughly calculated at about 112 millions, or about two-fifths of the population of Europe. The countries of which the established religion is Roman Catholic are—1, Italy; 2, Spain; 3, Portugal; 4, France; 5, Belgium; 6, Bavaria. In South America, the states formed by Spanish and Portuguese settlers are also exclusively Roman Catholic. Roman Catholic congregations are scattered about various countries of Asia, but in small numbers.

For the manner in which the pope carries on the spiritual government of this extensive flock, see CATHOLIC CHURCH and CONCORDAT. The form of election of the pope is given under CONCLAVE. For the history of the most distinguished popes, see their respective names in the BIOG. DIV. The reader may refer also to the 'Vitæ et Res Gestæ Pontificum Romanorum ab Initio nascentis Ecclesiæ usque ad Urbanum VII.,' by Ciaconio, Cabrera, and Vittorello, fol., Rome, 1630. A list of the succession of the popes will be found in Petau's 'Rationarium Temporum.'

POPLAR, ECONOMICAL USES. There are several varieties of poplar tree, which render useful service in the arts. The timber of the *white* poplar is very light coloured, and is used in France and Germany for a variety of minor purposes. It makes excellent packing cases, because nails may be driven into it without causing it to split. It is used extensively by turners and cabinet-makers. The boards and rollers around which pieces of silk are wrapped in merchants' warehouses and in shops are made of this wood, which is adopted on account of its lightness lessening the expense of freight. It is much used for flooring-boards, for large folding-doors for barns, and for other building purposes. It is used as a substitute for lime-tree in musical instruments. Wooden dishes and casks are occasionally made of it. The timber of the *black* poplar is used for much the same purposes as the white. It is yellow, soft, and easy to work; and is preferred by cabinet-makers for many purposes. It is used for clogs, the soles of wooden shoes, bowls and other turner's ware, and in cart-building. The *Lombardy poplar* produces wood less serviceable than that from the other varieties; but rafters, small beams, boards, &c., made of this wood and afterwards coated with tar, are found to be durable. The wood of the *Trembling poplar* or *Aspen* is white and tender; and is employed by turners; by coopers for herring casks, milk pails, &c.; by sculptors and engravers; by joiners and cabinet-makers; and by the makers of clogs, wooden shoes, butchers' trays, pack saddles, and a number of other articles.

As fuel, poplar wood is of inferior heating power; but it gives out its heat very quickly; the ovens belonging to most of the Paris bakers are heated by this wood. The bark of the black poplar is employed in tanning leather; when pulverised it is eaten by sheep; and being very thick, light, and corky, it is used by fishermen to support their nets, and even as corks for bottles. The bark of the aspen forms the principal food of the beaver; it is also usefully employed in medicine.

In Sweden the leaves of the white poplar are eaten by cattle. The buds of the black poplar, macerated in boiling water, and afterwards bruised in a mortar and pressed, yield a fat substance which burns like wax and exhales a fine odour. The balsamic sap with which the buds are covered forms the basis of an ointment that was much prized in former times. The young shoots may be used in basket-making; and the shoots with the leaves on are sometimes used as brooms. The cottony substance or flock that surrounds the seed has been used in Germany and France as wadding; and it has also been occasionally manufactured into cloths, hats, and paper. The *Balsam poplar* yields a balsam from the buds; it is collected from the trees in spring, at which season it collects into drops on the points of the buds. In Siberia a medicated wine is prepared from the buds.

POPLIN. Among the varieties of woven goods in which silk and worsted or silk and woollen are used in combination, poplin is one of the best and most esteemed. *Tabinet* is one form of this material; and Ireland has been distinguished for the excellence of its poplins and tabinets. The demand is now small, as other kinds of textile fabric have lately been more in favour; but the rich Irish poplins and tabinets, though employing only a small number of persons in their manufacture, maintain their high character.

POPULATION [CENSUS.]

POPULIN, *Benzoil-salicin* ($C_{26}H_{17}(C_{14}H_5O_2)O_{14}+4$ aq.) a peculiar product obtained from the bark and leaves of the poplar (*Populus tremula*). After extracting salicin from them, this remains in the mother water: carbonate of potash being added to it, a white precipitate is obtained, which is to be dissolved in boiling water. On cooling it crystallises in needleform crystals, which have an acrid and also a sweet taste, resembling that of liquorice. It dissolves in 70 parts of boiling water and in 2000 of cold water. Its solution in acids is precipitated by water. To sulphuric acid it imparts a red colour. The crystals contain 5·43 per cent. of water of crystallisation.

PORCELAIN. [POTTERY.]

PORCH (from the Latin *porticus*), a general term for any projection forming a covered space immediately before the entrance to a building, open in front, and more or less enclosed at its sides. The distinction between a porch and a portico is, that, however important it may be as a feature, the porch appears only a subordinate part of the building to which it is attached; whereas the portico [PORTICO] may be the whole of a front: therefore, though the term porch is usually employed only in speaking of the Romanesque and Gothic styles, it would be more correct and convenient to apply it, without regard to style, to what bears the character of a porch. By attending to such distinction, misconception would sometimes be prevented: for instance, if the Athenæum Club-house, London, were described as having a Doric portico, any one unacquainted with the design would imagine that the order was carried up as high as the general entablature of the building; whereas by terming it a Doric porch, such misconception would be avoided.

As far as we are aware, the only instance of a porch in Greek architecture is that in the octagonal structure called the Tower of the Winds, or that of Andronicus Cyrrhestes, which has a small prostyle portal on two of its faces, north-east and north-west, each consisting of a simple distyle, or two columns and their entablature, surmounted by a pediment; and which therefore may be regarded as the prototype of those ornamental compositions for doors and windows, so greatly affected in Italian architecture, which present a *microstyle* application of the orders, that is, small columns adapted not to the entire structure, but to subordinate parts of it.

When portico fronts were laid aside, as partaking too much of the previous Pagan temple; when columns began to be not only attached to the building, but employed as microstyle decorations to its different external stages or stories, often very irregularly, and generally connected together by arches; in short, when the Roman style was transformed into and superseded by the Byzantine and the Romanesque styles, porches began to be important features, subordinate indeed in size to the structures to which they were attached, but principal in regard to embellishment, being frequently composed of groups of small columns, elaborately wrought, and some of them often placed on the backs of lions or other animals, and supporting a series of concentric arches or archivolt mouldings equally enriched. Here microstyle embellishment may be said to have been carried to such a height as to be ultimately lost sight of: the columns became at length mere subsidiary members, and a combination of vertical mouldings or shafts cut out of the receding angles constituted the general splay of the whole portal, which was thus extended in appearance ad libitum, without regard to the size of the actual doorway or aperture itself, a very important advantage as regards design.

In the Norman-Gothic style, the porches or portals are little more than a modification of the similar features in Romanesque architecture. Of porches however strictly so called, that is, portals projecting out from the edifice, so as to form a sheltered external vestibule, we have comparatively few Norman instances, and those do not occur in the principal front, but at the sides of buildings. The same also is the case in Pointed Gothic architecture, where, though we often meet with spacious and magnificent portals, especially in continental examples, we do not find advanced porches brought out beyond the general plan of the building in front; the porch being there almost invariably enclosed within the lower part of the structure, even where it may be said to project with respect to that part of the front which is seen above it, but on a different plane, as for instance in the front of Westminster Hall, Winchester Cathedral, &c., although in those cases the entrances are placed rather within deep recesses than porches. In church architecture, entrances of the last-mentioned kind hardly ever occur at the west end or front, but were frequently made very conspicuous features in the side elevations, of which we have striking instances in the beautiful north porches at Salisbury and Wells cathedrals, both of which advance out very considerably. Some of the porches in our larger parish churches have a room above. [PARVISE.] Wooden porches are common in the smaller churches of every period of English pointed Gothic architecture.

In our ancient domestic architecture the porch, where it occurs at all, forms a marked, though not always a central feature, in the principal front. When it projects from the main structure, it is usually carried up so as to have a room, or else what forms a bay in a room, over it; and it is not unfrequently carried up higher than the rest, so as to form a kind of tower; or else the porch is recessed within the building, and presents externally merely an open arch. In many Elizabethan buildings, the porch, though forming a narrow compartment of the whole front, is profusely ornamented, even where the rest is quite plain. Kirby, in Northamptonshire, the seat of Lord-Chancellor Hatton, offers a most elaborate, not to say extravagant, example of the kind.

PORISM (*πόρισμα*). An intermediate class of propositions, between problems and theorems, was, as we are informed by Pappus, distinguished by the ancient geometers under the name of porisms. Unfortunately, however, the only notices of them by the ancients themselves, which are found in their remaining works, occur in the 'Collectiones Mathematicæ' of Pappus Alexandrinus, and the commentaries of Proclus on the Elements of Euclid, in both places so very imperfectly, that till of late years mathematicians were not agreed on their exact interpretation. The description of porisms by Pappus, which he gives in the preface to the seventh book of his above-mentioned work, in an account of Euclid's work on the subject, is, in all the manuscripts which have been examined, extremely mutilated, and every attempt to restore them, before the masterly hand of Robert Simson took up the subject, had completely failed. The first part of the description, which seems to be entire, is calculated only to excite curiosity, being too general for conveying any precise notion of these propositions, or for giving any effectual assistance for the recovery of them; and the remainder, containing a detail of the contents of Euclid's work, is through the whole so corrupt that all endeavours to explain it were nugatory. Several celebrated geometers indeed flattered themselves that they had obtained possession of the secret; but even Dr. Halley, with all his acuteness, relinquished the task, and adds, after giving the original, "hactenus porismatum descriptio nec mihi intellecta nec lectori profutura." The definition which Pappus quotes from the ancients is too general to be useful, and perhaps implied more than our acquaintance with the language in which he wrote can enable us to determine. He says that a "theorem is something requiring demonstration, a problem in which something is proposed to be constructed; but a porism, that which requires investigation;" and though this definition certainly does correspond to the nature of these propositions, yet it is deficient in discrimination, and of itself neither conveys any precise notion of Euclid's porisms, nor gives assistance in the investigation of any individual proposition. Dr. Simson's restored definition is as follows, literally translated:—"A porism is a proposition in which it is proposed to demonstrate that some one thing or more things are given, to which, as also to each of innumerable other things not given, but which have the same relation to those which are given, it is to be shown that there belongs some common affection described in the proposition." The following less literal translation may probably be better understood:—"A porism is a proposition in which it is proposed to demonstrate that one or more things are given, between which and every one of innumerable other things not given, *but assumed according to a given law*, a certain relation described in the proposition is to be shown to take place." Dr. Simson illustrates the propriety and accuracy of this definition by many examples, and it is so framed as to correspond with all the intimations of Pappus respecting porisms, and also with the character of the few individual porisms of Euclid which Dr. Simson had discovered. It may therefore justly be considered as expressive of the notions on this subject entertained by the ancients, although probably, as in the cases of theorem and problem, no precise definition was given of porism. It has been objected to Simson's definition, that it may be inferred from it that a porism partakes more of the nature of a problem than a theorem, and consequently is inconsistent with the "intermediate nature" mentioned by Pappus. In his enunciation it is affirmed that certain things *may* be found which shall have the relations or properties therein described. Now were it simply proposed to investigate certain things which would have the properties expressed in the porism, it may be regarded as a problem; but if these things are found by a construction described in the enunciation, the proposition becomes a theorem affirming the truth of the properties asserted; and then a demonstration only is required, without any investigation, in the manner which appears to have been practised by the later mathematicians alluded to by Pappus. The enunciation of a porism as a problem is not consistent with the usual character of such propositions. Problems usually, whatever difficulty may attend their solution, are almost immediately recognised, by those having some knowledge of geometry, as either possible in certain circumstances of the data, or as altogether impossible; and it would be unusual to propose as a problem "to find things with certain properties, respecting the possibility of which no judgment can be formed without an analysis, or such consideration as is equivalent to an analysis." For example, if it had been proposed as a problem in the time of Apollonius, to find in a given parabola a point having the property of the focus, that point being then unknown, such a proposition would not have been considered as a proper problem, but would in reality have been a porism. To take another example:—Proclus, in his commentaries on the Elements, mentions the first proposition of the third book, "to find the centre of a circle," as a porism, being in some measure between a problem and a theorem. But Proclus, however distinguished as a philosopher, was no mathematician, and as a circle, from Euclid's definition of it, must have a centre, the proposition to find that centre seems to be a proper problem. Had the circle been defined from another of its properties, as, for instance, from its being produced by the extremity of a straight line moving at right angles to another straight line, given in magnitude and position, and in the same plane, so that the square of the moving line be always equal to the rectangle by the segments into which it divides the given line; then the finding of the centre would be a proper porism, and might be enunciated thus:—"within a given circle (defined in the manner just mentioned) a point may be found from which all straight lines drawn to the circumference will be equal."

Having thus placed before our readers the most probable restoration of the ancient meaning of the term porism, we proceed to notice briefly what modern geometers have given us on the subject. First in importance stands the admirable paper on porisms by Professor Playfair, in the first volume of the 'Transactions of the Royal Society of Edinburgh,' which was read before that body in July, 1784. He improves on Simson's definition, and substitutes the following:—"A porism is a proposition affirming the possibility of finding such conditions as will render a certain problem indeterminate, or capable of innumerable solutions." This, it must be confessed, is an important and elegant simplification, and fully conveys every idea contained in the more prolix definition of Simson; but at the same time we agree with Dr. Trail in thinking that Dr. Simson's is expressed more nearly in the language and manner of the ancient geometers:—"Though I admire the ingenuity and fully admit the soundness of this definition, and also the utility of the principle on which it is founded in the discovery of porisms, I must acknowledge my doubt of that particular notion of a porism having ever been adopted, or even proposed, among the ancient geometricians." (Trail's 'Life of Simson,' pp. 50, 51.) A paper on porisms, containing some examples in the higher geometry, by Lord Brougham, was inserted in the 'Philosophical Transactions of the Royal Society,' in 1798. Fryer has given a popular history of the discovery of porisms, in the last edition of Simson's Geometry. Lastly, the most complete exposition of them that has yet appeared may be found in the 'Aperçu Historique sur l'Origine et le Développement des Méthodes en Géométrie,' 4to, Brus., 1837, by M. Chasles, of the French Institute: as well as in his recently published work, 'Les trois livres de Porismes d'Euclide, rétablies pour la première fois,' Paris, 1860, 8vo.

Porism was also used by the Greek geometers to denote a corollary to a proposition, and the frequent use of the word in this sense, as well as in the other, by Pappus and Proclus, has occasioned much confusion. Proclus says that "corollary is one of the geometrical appellations, but it has a twofold signification," and he proceeds to describe, in a very obscure manner, the difference between the two meanings of the term.

(See *Proclus in Euclidem*, edit. Hervagii, fol. Basil., 1533, fol. 18. We refer the reader also to Henry Savile's *Prælectiones in Euclidem*, 4to, Oxon, 1621, p. 18; and Trail's *Life of Simson*, p. 92.)

POROSITY is that condition of material bodies which consists in the discontinuity of their molecules, the intervals between these being called pores (from *πόρος*, a passage). Porosity is a property common to all bodies in nature, at least we know none in which the particles are contiguous to one another. By pores however we do not mean the *cavities* as in sponge and cork, which are visible to the eye, and scarcely those of other bodies which may be rendered so by the aid of a microscope. In bodies whose pores are not manifest, the existence of the intervals between the molecules is proved by various circumstances. Thus many of the metals become more compact by hammering, and all of them contract in bulk by a reduction of temperature. We may also refer to the Florentine experiment, for determining whether or not water is compressible,—the fluid was by pressure forced through the pores of the vessel of gold in which it was contained. Again, the porosity of bodies is inferred from their elasticity and the sounds which are heard when the molecules are in a state of vibration: also, in transparent bodies it is inferred from the fact that the particles of light pass through them, or that the vibrations of an ætherial fluid take place among the molecules.

When salt is dissolved in water, the particles of the salt seem to introduce themselves between those of the water, so that the volume of the mixture is less than the sum of the volumes of the separate substances; and the like may be said of the mixture of alcohol with water; in which cases the particles of one of the kinds of substance appear to enter and occupy the spaces between the particles of the other. The intervals between the particles of gaseous substances are very great; and though, in some cases, the volume of a mixture is equal to the sum of the volumes of the separate gases, yet, in others, it is equal to not more than $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, or $\frac{1}{8}$ of the sum of the separate volumes. A body of aqueous vapour composed of a volume represented by $2v$ of hydrogen gas, and a volume v of oxygen gas, is equal in volume to $2v$ only.

All material substances being subject to attractive forces, it has been made a question whether the attractions which take place between the molecules of bodies, and which are insensible at all appreciable distances from them, are the same as that general attraction which extends indefinitely through space; modified, however, by the figures and mutual distances of the molecules, by heat, electricity, and perhaps by powers which are at present unknown to us; but, in order that this hypothesis may be admissible, the dimensions of the molecules of bodies should be extremely small compared with those of the spaces among them; and the densities of the molecules immensely greater than the densities of the bodies themselves. La Place estimates ('Système du Monde,' ch. xviii. 4th edit.) that a molecule of a spherical form, whose diameter is one millionth part of a mètre, ought to have a density more than six million times as great as the mean density of the earth in order that it might exercise an attraction equal to that of terrestrial gravity; and he observes, that the attractive forces exercised by the molecules of bodies, which are probably only the excesses of the entire attractions of the molecules over the repulsive forces of the caloric in the intervals, must be vastly greater than that of gravity, since the actions of the molecules of a body produce visible inflexions of the rays of light, which cannot be asserted concerning the attraction of gravity. [ATTRACTION.]

PORPHYRIC ACID. [EUXANTHIC ACID.]

PORPHYROXINE. [OPIUM, ALKALOIDS OF.]

PORRIGO, *Ringworm*, is a pustular and contagious disease of the scalp, or, in some rare cases, of other parts where there is much hair. M. Biett describes two varieties of it under the names of *P. favosa* and *P. scutulata*. Dr. Willan described many more varieties, but he included in this name other widely different diseases.

Porrigo favosa consists of an eruption of small flat yellow pustules, with depressions at their centres, distinct or clustered, and which soon concrete into bright yellow honey-coloured scabs, on the surface of which the depressions of the centres of each pustule are usually still visible. After some time the scabs become thick and white; and drying, split and break off. Sometimes, however, they remain long adherent, the skin beneath them ulcerating, and the discharge oozing through them. The hair of the parts affected is always much loosened, and often falls off spontaneously; and, when it grows again, is weaker and lighter in colour than before.

Porrigo favosa appears rarely in any part except the scalp. It affects persons of all ages; but especially children from six to ten years old, and those who are naturally unhealthy, or ill-fed and dirty. It is distinctly communicable by contagion, and by this means may affect alike the weak and the robust.

It is one of the most obstinate diseases of the skin, and often lasts for months or years. The first measure for its cure is to cleanse the head completely with poultices or soap and water, and to have the hair cut very close. The dead hair and scabs must then be cleaned off as fast as they form. The medicines that promise the speediest success are lotions with sulphuret of potash or slightly acidulated, or with alkalies or their carbonates, such as in the following forms:—ten grains of potassa fusa in an ounce of water, to be applied occasionally; one or two drachms of subcarbonate of potash in a pint of water, to be constantly applied on linen; or from one to three drachms of sulphuret of potash to a pint of water; or from ten to twenty drops of any of the mineral acids to a pint of water, also to be constantly applied. Lotions also of sulphate of copper, nitrate of silver, and of nearly all the stimulant and astringent salts, have been employed, and sometimes with success; and in most cases of the disease, all these will have to be tried in turn, till one, being found beneficial, is continued till the cure is completed, or till it has ceased to do good, when it must be changed for another. Internal medicines must be employed if there be any symptoms indicating their necessity; but generally they are useless.

Porrigo scutulata, which is more commonly termed *ringworm* than the preceding, appears in the form of circular red patches, with numerous minute yellow pustules with depressed centres, out of which a hair usually projects, and which are attended by great itching. The fluid contained in the pustules dries up soon after they are formed, and, by coalescing, they produce a scab over the whole diseased surface. Subsequently successive crops of new pustules form around the margin of the scab, which is increased by their drying, and thus the disease may spread over the greater part of the scalp by the meeting and coalescing of the patches, which were at first isolated. The hair usually falls off from the part affected, or is so loosened that it may be pulled out without pain.

This form of porrigo sometimes appears spontaneously in poor and dirty children, but it is usually produced by contagion. The suggestions for its treatment must be the same as for Porrigo favosa.

PORT (Wine). [WINE.]

PORTCULLIS, in fortification, is a barrier formed of several large pieces of wood, joined across one another like a harrow, and each pointed with iron at the bottom. A portcullis was generally hung over the gateways of old fortified towns, ready to let down in case of a surprise, when the gates could not be shut. (James's 'Military Dictionary.') The French, at a very early period, called it "porte-coulant," that is, sliding gate, which is the true etymology of the word. "Coulisse" is likewise used by the French writers for the portcullis, whence our term is immediately derived.

PORTER. [BREWING.]

PORTFIRE is a composition consisting of saltpetre, sulphur, and mealed gunpowder, mixed together by being rubbed between the hands, and, after being passed through hair-sieves, moistened with spirits of wine: the mixture is then rammed or driven into a paper case of a cylindrical or conical form, and less than an inch in diameter. A piece of portfire sixteen inches long will burn from twelve to fifteen minutes.

It is generally used as a match for firing artillery, in which case the saltpetre, sulphur, and powder are in the proportion of 6, 2, and 1, respectively; but it is frequently employed in firing mines or in blasting rocks, when the proportions of the like ingredients are as 7, 2, and 8, respectively. For these last purposes the portfire is attached at the extremity of the train, or is inserted in the shaft bored in the rock or object to be blasted; and the fire is applied to it by a match.

PORTICO. Originally applied without distinction to colonnades and covered ambulatories, the term is now limited to signify a sheltered space enclosed by columns at the entrance to a building; and unless otherwise expressed, roofed with a pediment, like the end or front of a Grecian temple. The term therefore, as now generally restricted, answers to the *Pronaos* of such a temple.

According to the number of columns in front, porticos are said to be *tetrastyle*, that is, with four columns; *hexastyle*, with six; *octastyle*, with eight; *decastyle*, with ten; and *dodecastyle*, with twelve, the greatest number that can very well be brought beneath a pediment; and even of these two last the examples are exceedingly rare. If instead of columns at the angles there are antæ [ANTÆ], then the number of columns alone are reckoned as before, and denominates what is equivalent to a portico containing two more: thus a *distyle in antis*, that is, two columns between two antæ, is equal to a tetrastyle, as in both there are three intercolumns; a *tetrastyle in antis* is equal to a hexastyle, and so on. By means of this simple mode of numerical notation, a couple of words suffice to explain in the concisest manner what even a long description may leave doubtful: for instance, when we say that a portico is hexastyle Ionic, we clearly specify the order, and the number of columns in front; and it is upon this latter circumstance that so much of particular character depends. By way of example, we instance the following structures: distyle in antis, the church in North Audley Street; the entrance to the North-Western Railway Terminus, Euston Square, is a magnificent example of a distyle in antis, though not being an entrance attached to a building, it is rather a propylæum than a portico. Tetrastyle, portico of Hanover Chapel, Regent Street; tetrastyle in antis, Law Institution. Hexastyle, the porticos of St. Martin's; St. George's, Hanover Square; St. Pancras; Post Office; Italian Opera House, Covent Garden. Octastyle, portico of Royal Exchange; British Museum; the National Gallery; and decastyle, that of London University College.

Porticos are called *prostyle* when, as generally happens, they project from the main building. Such as are *in antis*, and recessed within the front of the building, are technically called *loggias;* the latter term indeed is not always employed in this particular sense, but it would be convenient if it were, as much ambiguity would thereby be prevented. The New Town Hall, Leeds, has a decastyle loggia. Although, too, a loggia so far resembles any other colonnade, it differs from it in being situated, like a portico, at the entrance and in the centre of a façade, whereas colonnades are usually lengthened ranges of columns in other situations; thus we speak of the "colonnades" of the Louvre, of Greenwich Hospital, and of the piazza of St. Peter's at Rome.

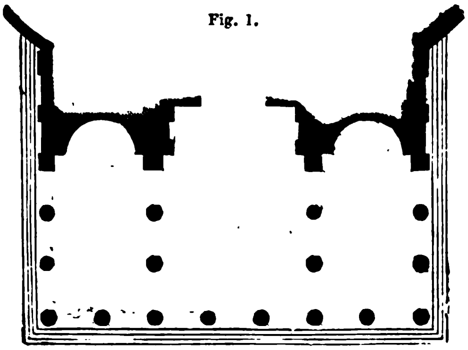
Pseudo-prostyle is a useful term suggested by Mr. Hosking for such an arrangement of columns beneath a pediment as resembles a prostyle in elevation, but which, instead of advancing forwards, forms merely a slightly projecting break, the portico itself being within the building, and nowise differing from a recessed loggia, except that it is not in *antis*, and is crowned by a pediment. Of this kind is the Ionic portico of the East India House, which, instead of being a tetrastyle *in antis*, is converted into a hexastyle by placing six columns in such manner that the end ones come immediately before the antæ or pilasters. The front of the Law Institution, Chancery Lane, may also be called pseudo-prostyle, because, although a loggia *in antis*, it is surmounted by a pediment.

Even in prostyle porticos there is great difference of character merely as regards the degree of projection given to them, independently of other circumstances; some are made to advance a single intercolumn, and others project considerably more. At the risk therefore of appearing to innovate upon the terminology of architecture, we would propose the following terms:—*monoprostyle*, where the portico projects only one intercolumn, as the Ionic hexastyle of St. Pancras church, London; *diprostyle*, where the projection is two intercolumns, as in the porticos of St. Martin's, Charing Cross, and St. George's, Bloomsbury, and so on; by which method the portico of the Pantheon at Rome might be briefly yet distinctly described as a Corinthian octastyle *triprostyle*, that is, a prostyle with eight columns or seven intercolumns in front, and three open intercolumns at its ends. Another circumstance, which it is highly important to note, is whether a portico be a simple prostyle, or be likewise *polystyle*, that is, whether the columns be merely external, or whether there are additional columns within the portico, as is the case with that of the Pantheon, which may therefore be further described as polystylar. The portico of the Kazan church, St. Petersburg, and those of the Glyptotheca at Munich, and Canova's church at Possagno, of which plans are given below, are also polystyle.

Some porticos again may be termed compound prostyles, because, while they project from the building, they also recede within it, as is the case with those of the London Post Office, University College, and Hanover Chapel, Regent Street; and such an arrangement gives greater effect as well as spaciousness, and prevents the portico from looking like a mere addition to the front of a building. Besides the varieties above enumerated, there are those which are semicircular in plan, of which the transept entrances of St. Paul's furnish very admirable examples; and another occurs in the pseudo-portico or portico-like compartment at the north-west angle of the Bank of England (*fig.* 10), which, owing to its being likewise recessed, and having columns behind those in front (not arranged concentrically, but placed on the chord to the outer curve), produces a rich and picturesque effect. Beautiful however as the semicircular form is, it becomes unsuitable for such purpose if a portico so shaped cannot be made equal to a hexastyle, or a tetrastyle in antis, that is, have five intercolumns, because if there be only three, either the whole portico must be very narrow in proportion to its height, or the intercolumns so wide that the architrave over them will considerably overhang a line drawn from one column to another, and thereby produce an appearance both of deformity and weakness.

Respecting the temple-porticos of the ancients, or rather the external arrangement of columns in such edifices, whether confined to the ends or continued along the sides, we refer to the article TEMPLE, where they will be found sufficiently explained; and shall now briefly pass in review some of the porticos that most deserve notice on account of their *plan*, to which we shall confine our attention, passing over all other circumstances. We shall not therefore attend to the order of columns employed in them, nor take any account of their dimensions, the plans being drawn not to the same scale, but for convenience sake, nearly to the same size. We commence with that of the Pantheon at Rome (*fig.* 1), attached to a circular edifice, and which, as will instantly be seen, is decidedly different from the usual portico at the end or front of a temple, or from those monoprostyles, or single external line of columns, which constitute the generality of modern porticos.

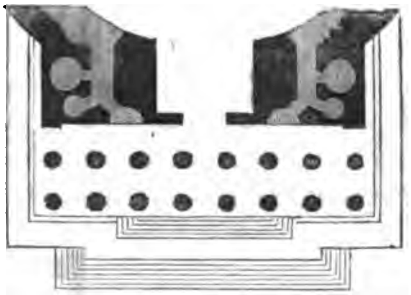
Fig. 1.



Besides being triprostyle, or having three open intercolumns on its flanks, it may be described as polystyle, having columns within, dividing it into three avenues or aisles, the centre one of which is extended by being considerably recessed, a circumstance that adds very greatly to the general effect.

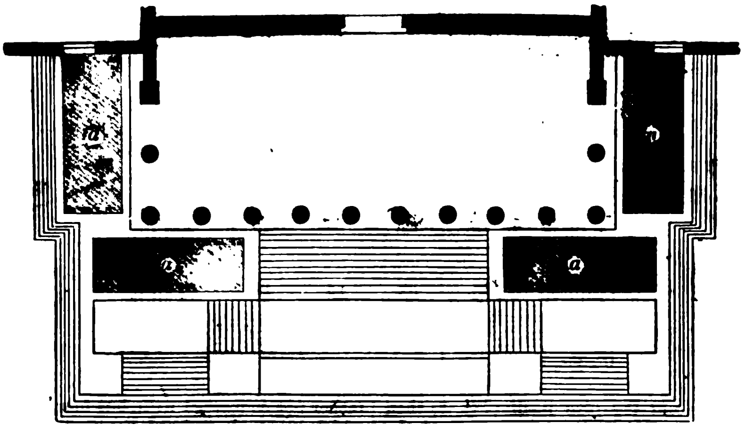
As being, like the preceding, attached to a rotunda, we have selected for the next plan that of the church erected by Canova at Possagno (*fig.* 2). This also is a polystyle, though altogether different in its arrangement from the other, there being here merely a second range of columns behind those in front, on which account it might be designated a double octastyle.

Fig. 2.



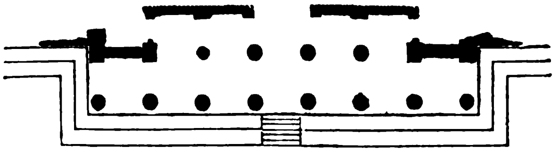
As an example of a decastyle portico, we give that of University College (*fig.* 3), which instead of being merely monoprostyle, or single line of twelve columns, beneath a pediment, projects forwards very considerably, it being equal to a triprostyle, or a pseudo- triprostyle, with one intercolumn closed up, owing to which it appears internally to be partly recessed, to be carried out two intercolumns, and inwards for the space of one. This example is further remarkable on account of the unusual and picturesque arrangement of the steps forming the ascent up to it, which commence below on each side, while above they form a single broad flight, in such manner as to leave screened areas, *a a*, which serve to admit light to the spaces in the basement beneath the portico.

Fig. 3.



The portico of the Glyptotheca at Munich (*fig.* 4) may be described as monoprostyle, recessed, and polystyle, it being compounded of an octastyle advanced only one intercolumn before the rest of the front, and of a tetrastyle in antis behind it, forming five open intercolumns, the extent of the recessed part, by which means not only great richness of columniation, but a picturesque play and contrast are obtained.

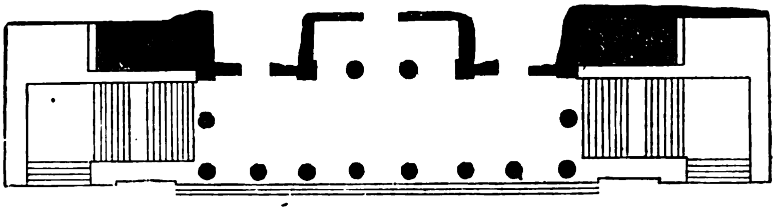
Fig. 4.



Like that of University College, the portico of the National Gallery (*fig.* 5) is pseudo-triprostyle, consequently projects as much as three intercolumns from the building; but, in other respects, differs very materially from it, being only partially recessed in the centre, where are two columns forming a distyle in antis. It also differs from the other example altogether in the arrangement of the steps leading up to it.

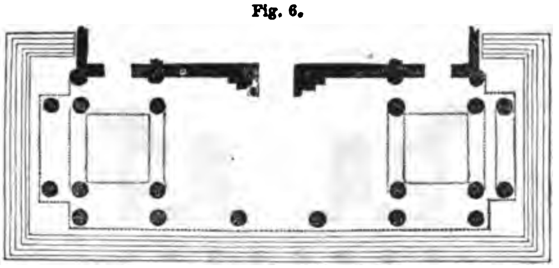
The portico of the Pantheon at Paris (*Fig.* 6) offers a more singular than judicious arrangement, two columns being projected at each end so as to produce a group of three at the external angles, which, although by no means displeasing in the ground-plan, produces an awkward effect in the structure itself or an elevation of it; because,

Fig. 5.



instead of being included beneath the pediment, these columns and their entablature form mere little jutting-out bits, attached to the flanks, and almost suggest the idea of its being originally intended to continue them as lateral colonnades parallel to the hexastyle beneath the pediment (as in the next figure). Though this portico is only hexastyle in front, and has only four columns within, there are eighteen columns altogether, besides the half and three-quarter columns attached to the wall behind, a number sufficient to have formed an octastyle triprostyle with six inner columns, namely, four disposed as in the portico of the Pantheon (*Fig.* 1), and two forming a pronaos recess for the centre doorway, as in *Fig.* 5.

Fig. 6.



Our next example, which is the portico of the Fitzwilliam Museum at Cambridge (*Fig.* 7), differs materially from the foregoing one, presenting a richer system of columniation in some respects; for though, technically speaking, no more than a monoprostyle octastyle, it is extended by lateral loggias, three intercolumns in width, and has besides considerable depth within.

Although only a hexastyle, the portico of the Kazan Cathedral, St. Petersburg, towards the Nevsky Prospect, is an unusually rich example of a polystyle prostyle, and of certain peculiarities of arrangement which will be better understood from the plan itself (*Fig.* 8) than from any verbal explanation. The cut also shows a portion of the sweeping colonnades (in imitation of those by Bernini in the Piazza di San Pietro at Rome), and the mode in which they are connected, or rather not connected with, but merely brought up to the portico itself, which is so awkward and disagreeable as materially to detract from the effect of the whole.

Fig. 7.

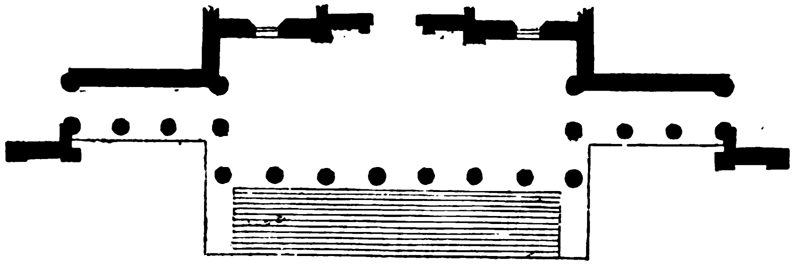


Fig. 8.

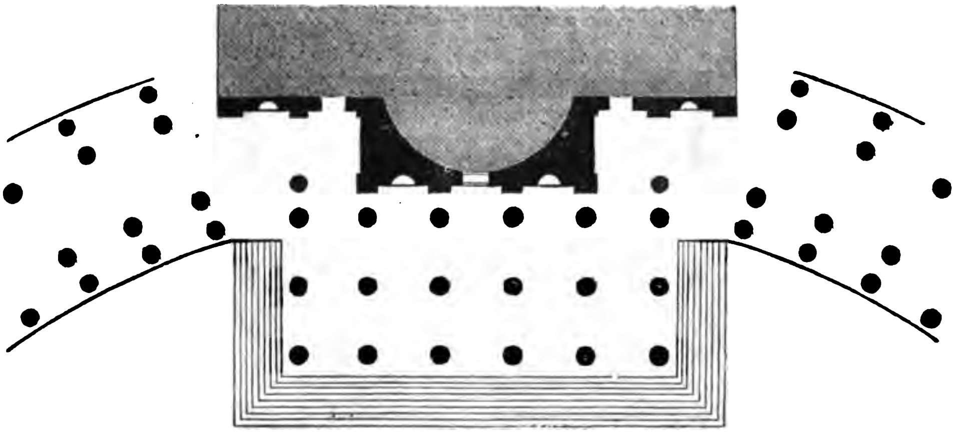
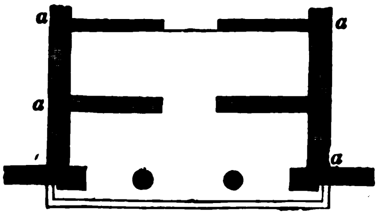


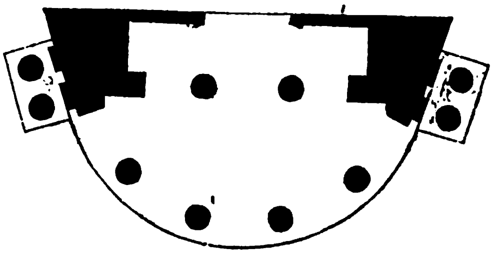
Fig. 9.



Mr. Gandy Deering's small Doric distyle in antis, in the front of the building originally erected for the Pimlico Proprietary School in Ebury Street (*Fig.* 9), affords an example of a portico with an inner screen carried up half way behind the columns, and with lateral openings at the ends of the portico between small antæ, *a*, *a*, &c., descending as low as the top of the screen, and two of them resting on its exterior ends. The idea is a valuable one, and admits of almost endless diversity and new combinations.

The only other example we shall offer is that of the semicircular, or rather segmental loggia, forming the north-west angle of the Bank of England (*Fig.* 10), the most tasteful and picturesque piece of design that Sir J. Soane ever produced. The effect of the inner columns, the contrast they afford to the others, their shafts being plain, while the rest are all fluted, the varied perspective appearance accordingly as the spectator shifts his station, and the great play of light and shade, all render this little bit quite an architectural study.

Fig. 10.



PORTRAIT (*Portrait*, French; *Ritratto*, Italian; *Bildniss*, German; *Imago*, Latin; *εἰκών*, Greek). A portrait, strictly speaking, signifies the likeness of anything whatever, whether animate or inanimate, either drawn or coloured upon a flat surface: in a more restricted sense it signifies a drawing or a painting representing the likeness of any particular individual; but it is also frequently applied to the pictures of animals.

Portrait, says Lord Orford, is the only true historical painting. Its uses are manifest; it administers to the affections, it preserves to the world the features of those who, for their services, have merited the gratitude of mankind, and of those who have been in any way remarkable for their own actions or through their position in society; and in a simply historical point of view, it illustrates the costume and habits of past ages. In all or nearly all these respects photographic portraiture is of almost inestimable value; but our immediate subject is portrait painting, and to that we must confine our attention. We may, however, remark that it is only by a studious regard to the principles which lead to excellence in portrait painting, that satisfactory results can be obtained in photographic portraiture.

Portraiture seems to be almost as ancient as the art of painting itself; indeed, according to the romantic legend told by Pliny ('Hist. Nat.' xxxv. 12, 43), it was in Greece the origin of the imitative arts; an enamoured Corinthian maid traced the profile of her lover around his shadow cast by a lamp upon the wall.

The most ancient portraits extant, if they can be termed such, are those which have been found in the cases of mummies: there is a singularly fine specimen of these preserved in the Egyptian museum of the Louvre in Paris; and there is also one in the British Museum.

It was a custom among the ancients, in very early times, for warriors to have their portraits painted upon their shields, called by the Romans *imagines clipeorum*, or *imagines clipeatæ*, and these shields were frequently dedicated in the temples in honour of their owners when deceased, or placed by victors as trophies (clipei votivi). The portraits were most probably painted in wax, but that they were well executed is very doubtful. (Pliny, xxxv. 3.)

Among the Romans, in the time of the republic, the possession of the portraits of their ancestors (*imagines majorum*) was a proof of nobility, for by the *jus imaginum* none were permitted to make portraits of themselves except those who had themselves or whose ancestors had borne some curule magistracy; and Roman families were accustomed to boast of their *famosæ imagines* as a proof of their ancient nobility. (Cic., 'In Pisonem,' 1.) These portraits or images, which were of wax, were preserved with much care by their posterity, and were only brought out upon great occasions or carried before them in funeral processions. (Pliny, xxxv. 2.) They were probably painted busts, for the art of casting with wax in plaster moulds taken from the life was, according to Pliny (xxxv. 12, 44), invented as early as the time of Alexander, by Lysistratus the brother of Lysippus. It seems that the Romans were also sometimes in the habit of prefixing the portraits of authors to their works. Martial mentions one of Virgil (xiv. 186).

The most ancient portrait-painter of extraordinary merit on record was apparently Dionysius of Colophon: he is praised by Aristotle ('Poet.,' 2) for the fidelity of his paintings; and from what Plutarch says ('Timol.,' 36) of the high finish of his works, we may perhaps term him the Holbein of antiquity: he flourished, as nearly as can be ascertained, shortly after the time of Polygnotus and Phidias, about 430 B.C.

The most famous portrait-painter among the ancients was Apelles: he enjoyed the exclusive privilege of painting the portraits of Alexander: one of his most celebrated pictures was a portrait of that monarch as Jupiter, called the "Alexander Ceraunophoros," for which, according to the incredible account of Pliny (xxxv. 10, 36), he received 20 talents of gold (upwards of 50,000*l.* sterling); so large a sum, that it was measured to the painter, not counted ("mensura, non numero"). Most of the pictures of Apelles were portraits in an extended sense, yet it is doubtful whether before the time of the Roman emperors there was a distinct class of painters who confined themselves to portraits ("imaginum pictores:" Pliny, xxxv. 11, 40). Even in the great days of Italian art there was not a distinct class of portrait painters as in the present times; and it is an incontestable fact, that although upon the whole the number of good portrait painters has very much increased, still portrait-painting itself has not improved since such has become the practice.

The success of a portrait depends upon the sitter as well as upon the painter, and it may be spoiled by the bad taste of the one or the other. Excellence in portraiture consists in placing every feature in its proper place, in a correctness of modelling, a judicious arrangement of light and shade suited to the complexion of the subject, and in tasteful attire and an unaffected and simple attitude; the former are within the province of the painter, the latter in that of the sitter. Much of the character may be shown by the posture, and the painter should adopt that which appears most natural to his sitter, for the habits of nature must be distinguished from those of fashion; no defect is more striking in a portrait than a forced and affected attitude.

In every portrait the countenance of the person represented should constitute the picture; all accessories must be kept subordinate to the principal object, and should not engage the attention except when expressly examined, for they are the mere adjuncts necessary to indicate the character, rank, or nation of the original. Upon these principles a good portrait must be a good picture, for the beauty of a picture consists in the harmony of the whole in composition, colour, and execution: and when every part has received no more of the painter's attention than its local importance requires, a picture cannot in any particular deviate from the truth, simplicity, and unity of nature. Fancy costumes are injurious to portraits as portraits, for a general resemblance being the principal object of portraiture, the subject should be clothed as usual, and the more simple the attire, the more prominent and consequently the more important will be the head, which is the principal object. Whatever deviations are allowed from this principle, although the picture may perhaps gain in pictorial effect, it must lose as a portrait. A mere insipid transcript of the features, and an equally minute attention to the detail of the accessories, are a degradation of portrait. There is no other difference between historical painting and portrait painting than that portrait exacts a stricter attention to the individual character, and consequently requires a more careful execution of the head, but the draperies and accessories should be equally bold and free as in historical painting. Large canvasses, and what are termed full-lengths, are ill suited to portrait, and the latter are seldom successful even under the most able hands. How often we see a great field of canvass, where the head is a mere speck, and is generally lost in the mass of accessories, of trees, columns, or draperies; these are pictures of robes, not of men, and are only tolerable as state portraits, when the insignia of rank or office are more important than the individuals. Such should be termed Iconics (*εἰκονικοί*) rather than portraits.

Expression is perhaps the most important study in portrait. To represent the true character of an individual, the countenance should be painted in repose, when no particular sentiment or passion predominates; for an otherwise good picture may be rendered a very bad portrait through the injudicious adoption of some transitory expression, or the introduction of a smile put on for the occasion, when perhaps the mouth is smiling whilst the eyes are languid and fatigued. The expression may be also materially injured by exaggerating the local tints, which in most cases has the effect of changing the complexion, and the particular expression of every individual depends upon the complexion as well as upon the relative proportions of the features. It is by accurately giving these proportions that what is called a striking likeness is produced, and this may be accomplished without entering into any minute detail of the parts; the features are indicated rather than expressed: this is a principle of historical painting, but is a style only fit for the portraits of public characters, or such as are to be placed in spacious localities, and must be viewed at a distance.

Such portraits, when even of only tolerable resemblance, are generally pronounced to be striking likenesses, especially by those who have but an imperfect knowledge of the persons represented; for they are themselves unacquainted with any more of the physiognomy of the originals than they see expressed in the pictures. These portraits however lose their resemblance either upon close inspection or upon a prolonged view.

The most successful painters of portrait in modern times have been Lionardo da Vinci, Raffaelle, Sebastian del Piombo, Giorgione, Paris Bordone, Titian, Velasquez, Holbein, Hals, Rembrandt, and Vandyck; and the following pictures are amongst the finest specimens of portrait painting extant:—his own portrait by Lionardo da Vinci, in the portrait gallery at Florence; Andrea Doria, by Sebastian del Piombo, in the Palazzo Doria at Rome; the head of Guido, by Simone Cantarini, in the Academy at Bologna; Titian and Aretin, by Titian, in the royal collection at Windsor; Pope Innocent X., by Velasquez, in the Palazzo Doria at Rome; the Meyer Family, by Holbein, in the gallery at Dresden; and the head of Gevartius, by Vandyck, in the National Gallery in London.

Of the portrait painters of more recent times, Mengs, Reynolds, Gainsborough, David, Gerard, and Lawrence have enjoyed the greatest celebrity.

POSEIDON (Ποσειδῶν), one of the deities of the Greek Olympus.

The attributes of the Roman *Neptunus* or *Neptumnus*, are nearly the same as those of the Greek Poseidon. Poseidon was the son of Kronos and Rhea, and the brother of Zeus and Hera, and appears to have been one of the ancient divinities of Greece; although, according to Herodotus (ii. 50), he was not originally a Greek deity, but was introduced from Libya. Poseidon was the god of the water in general, of the sea, the rivers, and the fountains; but he was more particularly regarded as the god of the sea, which he acquired as his share in the division of the dominions of his father Kronos. His wife was Amphitrite, and their son Triton.

Poseidon is said to have produced the horse in his contest with Athene for the right of naming the city of Athens. It is difficult to give a reason for the connection of Neptune with the horse; but it is evident from several passages in the Greek writers that he was regarded as a kind of equestrian deity, as well as the god of the sea. (Aristoph., 'Knights,' l. 449.) Poseidon had a magnificent palace beneath the sea at Ægæ ('Il.,' xiii. 20). The animals offered to him in sacrifice were usually black bulls, rams, and boar pigs.

Poseidon was not originally a god of the Doric race. He was principally worshipped by the Ionians, who were in most places a maritime people. In those Dorian cities, however, which had acquired a love for foreign commerce, we find that the worship of Poseidon prevailed extensively; as, for instance, at Tænarum, whence it was carried to Tarentum, at Cyrene, in Ægina, and more particularly on the Corinthian isthmus, and at Trœzen, from which place the worship of this god was transmitted to Posidonia in Italy. (Müller's 'Dorians,' vol. i., p. 417, 418, tr.)

The etymology of the names Poseidon and Neptunus is doubtful. Poseidon is written in Doric Greek, Poteidan (Ποτειδᾶν), of which we have another example in the name of Potidæa, written Poteidaia (Ποτειδαία) in the inscription, now in the British Museum, on those Athenians who fell before this city. The name, according to some writers, contains the same root, in the first syllable, as we find in *ποτός* and *ποταμός*. Neptunus is derived by Cicero from *nando* ('Nat. Deor.,' ii. 26); and by Varro from *nuptu*, because this god covers (*obnubit*) the earth with the sea ('De Ling. Lat.,' iv. 10); but neither of these derivations has the least show of probablity. We may compare the form of the word Nept-unus or -umnus, with Port-umnus, Vert-umnus, and the word al-umnus; but the meaning or origin of the root *Nept* or *Nep* seems uncertain. It may perhaps be connected with the same root as is contained in the Greek *νίπ-τω*.

The statues of Poseidon resembled in many respects those of Zeus; but the figure of the former was more angular, and there was less of repose and thoughtfulness in the countenance. The Greek sculptors gave a certain degree of roughness to the statues of Poseidon, which appears to have been regarded as appropriate to the god of the ocean. His hair was usually somewhat in disorder, and the whole of his figure was represented as exceedingly powerful and muscular. Hence the "chest of Poseidon" (*στέρνον Ποσειδάωνος*, 'Il.,' v. 479) is the poetic expression for this characteristic of the deity, which is illustrated by the noble fragment from the pediment of the Parthenon in the British Museum. He was usually fully draped. His right hand held the trident; and he was frequently represented accompanied by Amphitrite, or surrounded by Nereids, Tritons, dolphins, and other marine personages and objects. (Müller, 'Archäologie der Kunst,' §§ 354–56; 'Denkmaler der Alten Kunst.')

POSITIVE. [Negative Quantities.]

POSSE COMITA'TUS (literally, the power of a county) comprise all able-bodied males within the county between the ages of 15 and 70 years. All such persons, without any exception, are bound to aid the sheriff in all matters that relate to his office; and he is fineable if he neglect to avail himself of their aid. In case of any invasion, rebellion, riot, &c., or breach of the peace within the county, all such persons, on pain of fine or imprisonment, are bound to attend him on being charged by him to do so, and to assist in opposing and suppressing them. They may come armed, and are justified in killing a person in case of resistance. The power of the county may also be raised when necessary for the purpose of apprehending traitors, felons, &c., and that even within particular franchises. It is lawful for any peace-officer, (and perhaps even for a private person,) to raise a competent number of people for the purpose of opposing and suppressing enemies, rebels, rioters, &c. within the county; but such persons are punishable if they use unnecessary violence. It is also the duty of the sheriff or any minister of the king having the execution of the king's writs, or process even in a civil nature, who meets with actual resistance in his attempt to execute them, to raise a power sufficient to quell the resistance. (2 Inst., 193, 194; 3 Inst., 161; 1 Hawk., P.C., 152, 156.)

POSSESSIO FRATRES. [Descent.]

POSSESSION. In endeavouring to explain the legal meaning of this term, we shall commence with the following extracts from Savigny's work on the Right of Possession ('Das Recht des Besitzes,' Giessen, 1827.)

"All the definitions of possession are founded on one common notion. By the notion of possession of a thing we understand that condition by virtue of which not only are we ourselves physically capable of operating upon it, but every other person is incapable. This condition, which is called detention, and which lies at the foundation of every notion of possession, is no juristical notion, but it has an immediate relation to a juristical notion, by virtue of which it becomes a subject of legislation. As ownership is the legal capacity to operate on a thing at our pleasure, and to exclude all other persons from using it; so is detention the exercise of ownership, and it is the natural state which corresponds to ownership as a legal state. If this juristical relation of possession were the only one, everything concerning it that could juristically be determined, would be comprehended in the following positions:—the owner has the right to possess; the same right belongs to him to whom the owner gives the possession; no other person has this right.

"But the Roman law, in the case of possession, as well as of property, determines the mode in which it is acquired and lost; consequently it treats possession not only as a consequence of a right, but as a condition of rights. Accordingly, in a juristical theory of possession, it is only the right of possession (jus possessionis) that we have to consider, and not the right to possess (called by modern jurists jus possidendi), which belongs to the theory of property.

"We now pass from the notion of mere detention to that of juristical possession, which is the subject of this treatise. The object of the first part, which is the foundation of the whole investigation, is to determine this notion formally and materially. Formally, by explaining those rights which presuppose possession as a condition, and consequently determining the signification which the non-juristical notion of detention obtains in jurisprudence, in order to its being considered as something juristical, that is, Possession; materially, by enumerating the conditions which the Roman law requires for the existence of possession, and consequently the positive modifications under which detention can be viewed as possession.

"The formal determination of the notion by force of which alone possession can become a subject of jurisprudence, is divided into three parts; first we must determine the place which possession, as a legal relation, occupies in the system of Roman law. We must then enumerate the rights which the Roman law recognises as a consequence of possession, and we must also examine the rights which are improperly considered rights of possession. It will then be easy to answer the questions whether possession is to be considered as a right, and whether as a jus in re. The first and simplest mode in which possession appears in a system of jurisprudence consists in the owner having the right to possess; but we are here considering possession independent of ownership, and as the source of peculiar rights; the former of these two questions therefore may be expressed thus—in what sense has possession been distinguished from ownership? a mode of expression which has been used by many writers.

"In the second place we must determine how the different senses in which possession occurs in the Roman law are distinguished from one another by the mode of expression; and particularly what were the significations of possessio generally, and possessio naturalis, and possessio civilis, among the Roman jurists.

"In the whole system of Roman law there are only two consequences which can be ascribed to possession of itself, as distinct from all ownership, and these are usucapion and interdicta.

"The foundation of usucapion is the rule of the Twelve Tables, that he who possesses a thing one or two years becomes the owner. In this case bare possession, independent of all right, is the foundation of property, which possession must indeed have originated in a particular way, in order to have such effect; but still it is a bare fact, without any other right than what such effect gives to it. Accordingly it is possession itself, distinct from every other legal relation, on which usucapion, and consequently the acquisition of ownership, depends.

"Possessorial interdicts are the second effect of possession, and their relation to possession is this: possession of itself being no legal relation, the disturbance of possession is no violation of a legal right, and it can only become so by the circumstance of its being at the same time a violation of a legal right. But if the disturbance of possession is effected by force, such force is a violation of right, since every forcible act is illegal, and such illegal act is the very thing which it is the object of an interdict to remedy. All possessorial interdicts then agree in this: they presuppose an act which in its form is illegal.[*]

"Now since possessorial interdicts are founded on such acts as in their form are illegal, it is clear why possession, independent of all regard to its own rightfulness, may be the foundation of rights. When the owner claims a thing as his property (vindicatio), it is a matter of perfect indifference in what way the other party has obtained possession of it, since the owner has the right to exclude every other person from the possession of it. The case is the same with respect to the interdict, by which the 'missio in possessionem' is protected: this interdict is not a possessorial interdict, for the 'missio' itself gives no possession, but it gives a right to detention, and this right is made effective in the same way as in the case of property. On the other hand, he who has the bare possession of a thing has not on that account any right to the detention, but he has a right to require from all the world that no force shall be used against him. If however force is used and directed against the possession, the possessor protects himself by means of the interdicts. Possession is the condition of these interdicts, and in this case, as in the case of usucapion, it is the condition of rights generally.

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[*] Possessorial interdicts were not limited to cases of violence; they comprehended the three *vitia possessionis*. (Terence, 'Eunuch.,' ii. 3; v. 27.)

"Most writers take quite a different view of the matter, and consider every violation of possession as a violation of a legal right, and possession consequently as a right of itself, namely, presumptive ownership, and possessorial plaints as provisional vindications. This last, which is the practical part of this opinion, is completely confuted in a subsequent part of this treatise; but it is proper to show here how far such a view is true, as this may be a means of reconciling conflicting opinions. The formal act of illegality above mentioned is not to be so understood, as if possessorial interdicts were a necessary consequence of the independent juristical character of force, and obviously sprung out of it. This consequence of force, namely, that possession of the thing must be restored to the person who has been ejected, without regard to the question whether or not he has any right to the thing, is rather simply a positive rule of law. Now if we ask for the reason of this kind of protection being given against force, that is, why the ejected party should recover the possession to which he may possibly have no title, it may be replied, that the reason is the general presumption that the possessor may be the owner. So far then we may view possession as a shadow of ownership, as a presumed ownership; but this view of the matter only extends to the establishment of the rule of law in general, and not to the legal reason for any particular case of possession. This legal reason is founded rather in the protection against the formal injury, and accordingly possessorial interdicts have a completely obligatory character, and can never be viewed as provisional vindications."

The special object of Savigny's essay may be collected from these passages. The legal principles here developed are applicable to every system of jurisprudence. There must always be a distinction between the right to possess, which is a legal consequence of ownership, and the right of possession, which is independent of all ownership. The owner of a thing may not have the possession, but he has a right to the possession, which he must prosecute by legal means. The possessor of a thing, simply as such, has rights which are the consequences of his possession; that is, he is legally entitled to be protected against forcible ejection or fraudulent deprivation; his title to a continuance of his possession is good against all persons who cannot establish their right to the thing, and this continued possession may, according to the rules of positive law in each country, become the foundation of ownership. It may be that the acquisition of possession may also be the acquisition of ownership, or that the acquisition of possession may be essential to the acquisition of ownership. Thus, in the case of occupation, the taking possession of that which has no owner, or the acquisition of the possession, is the acquisition of the ownership. Also, when a thing is delivered by the owner to another, to have as his own, the acquisition of the possession is the acquisition of the ownership. In these examples, ownership and possession are acquired at the same time, and there is no right that belongs to the possessor as possessor: his rights are those of owner. But the form and mode of the acquisition of the possession, viewed by itself as distinct from the acquisition of the ownership, will also be applicable to the cases of possession when possession only is acquired. For possession of itself is a bare fact, though it has legal consequences; and being a bare fact, its existence is independent of all rules of the civil law or of the jus gentium, as to the acquisition and loss of rights. (Savigny, p. 25.)

Having shown that in the Roman law all juristical possession has reference to usucapion and interdicts, and that the foundation of both is a common notion of juristical possession, Savigny proceeds to determine the material conditions of this notion.

In order to lay the foundation of possession as such, there must be detention, and there must also be the intention to possess, or the "animus possidendi." Consequently the "animus possidendi" consists in the intention of exercising ownership. But this ownership may either be a person's own ownership or that of another: if the latter, there is no such "animus possidendi" as makes detention amount to possession. In the former case a man is a possessor, because he treats the thing as his own: it is not necessary that he should believe it to be his own.

Whether then we are considering possession as such, or that possession which is concurrently acquired with ownership, or which completes the acquisition of, or is the exercise of, ownership, the material facts of possession are the same. When ownership is transferred from one man to another, every system of law must require some evidence of it. But the evidence of the transfer of ownership may be entirely independent of the evidence of acquisition of possession; and also the evidence of the acquisition of possession may be inseparable from that of the acquisition of ownership. There must then generally be some act which shall be evidence of the acquisition of possession, whether possession as such is obtained without ownership, or possession accompanied by ownership, or possession as necessary to the complete acquisition of ownership, or possession as simply the exercise of ownership.

Bracton, the oldest law writer from whom we obtain any comprehensive notion of our whole system, has framed his notions of possession on and borrowed his definitions from the Roman law. Whether he has always rightly understood them is a matter that would require a very careful investigation.

Bracton (c. 17) uses possessio and seisina as synonymous. He observes that it is not sufficient for one man's right to be transferred to another, unless that other obtain "seisina;" and he adds, "possessio sive seisina multiplex est." He defines possessio to be "corporalis rei detentio i., corporis et animi cum juris adminiculo concurrente." He therefore limits it to corporeal things, for incorporeal things are incapable of tradition or delivery, but may be said "quasi possideri;" and he requires both the corporeal act and the animus together with right, in order to give possessio, which, thus understood, is complete ownership. Accordingly verus possessor is owner. (Fleta, iii., c. 3, s. 1.) He divides possessio into "civilis, quæ animo tantum tenetur," that is, in which there is an intention to hold; and "naturalis, quæ corpore;" and this latter may be just, that is, with good title; or unjust, that is, without good title. To acquire complete possession, it must be acquired "animo et corpore:" there must be both the mental affection *possidendi affectus* (as Bracton elsewhere calls it, fol. 40) and the corporeal act; possession can only be completely lost "animo et corpore," for it may be lost "corpore," and retained "animo." Among various kinds of possession he enumerates nuda, where a person has no right to the thing; and vestita, where he has "jus, titulus, tempus." As an instance of a case, where there is "nihil juris in re, sed aliquid possessionis," he mentions the case of a man being seised or possessed by intrusion. As another kind of possession, but which is manifestly distinguishable from the others, he mentions the possession of a custos creditor, or any person of the kind. These examples will be sufficient to show that the senses of possessio at that time were very various. The essential part of all of them is detentio.

In the transfers of freeholds, mentioned by Bracton, traditio or livery is defined to be "in possessionem inductio de re corporali;" as soon as this traditio is made by the owner, the person to whom it is made has "liberum tenementum," a freehold estate (Bracton, fol. 39), "propter conjunctionem juris et seisinae et mutuum utriusque partis consensum."

A person who held land for a term of years (firmarius) had no "liberum tenementum" (fol. 27), but he was certainly said "possidere," but there was not the "conjunctio juris et seisinae," that is, a possessio which made a liberum tenementum. Again (c. 15), when Bracton is treating of one cause or title of possession being turned into another, he says that he who has the usus fructus and the terminus, or term of years, may, during its continuance, and while he is thus in possession, acquire "liberum tenementum," if the proper formalities are observed, "so that there shall not be wanting proof of the new acquisition." It appears that the owner (dominus) was not said to possess during the continuance of the term; for it is said (fol. 32) "that the donor and true owner, with the consent of the tenant (tenens), might change one title of possession into another without any change of the possession; nor is it necessary to resume the thing that has been once given and possessed, in order that it may be possessed by a new title."

It remains to attempt to show some of the many senses in which possession has been or is still used in English law. There seems to have been always a fundamental distinction as to the use and meaning of this word, between land and moveable chattels, of which something more will presently be said. Some of our old writers make the following division of possession as applied to land: "Possession is actual and in law: *actual* possession is when a man actually enters lands and tenements to him descended; possession *in law* is when lands and tenements descend to a man, and he hath not yet actually entered into them." (Staundf., 'Pl. Cor.,' fol. 198; Cowel.) Now, this actual possession, that is, possessio according to Bracton's definition, is the only possession included in this definition, that is, properly so called. The possession in law is merely the owner's right to possess. This possession in law, that is, ownership and the right to possess is not full ownership, for if the right to possess is not exercised, that is, does not become an actual possession, it will be lost in course of time. (3 & 4 Wm. IV., c. 27.) It becomes an actual possession by entry, that is, by the owner entering on the land or exercising ownership over it. What shall be sufficient to constitute entry so as to give the owner all the advantages of actual possession, may sometimes be difficult to determine; but actual entry is not always necessary for that purpose. The receipt of the rent from a lessee for years, who has the actual possession of the land, gives to the owner all the legal advantages which are derived from his actual entry.

A lessee for years, who pays a rent, has the actual possession of the premises, and if the landlord enters the premises, except when rent is in arrear, or by virtue of the covenants in the lease, he is a trespasser. Still the owner who receives the rents is often said, in a sense, to be in possession, though he may never have had actual possession. This sense of possession is that which is expressed in the recent Statute of Limitations by the words "receipt of the profits." It might be called "legal possession," as it is for many purposes a possession which gives all the advantages of actual possession. But since "legal possession" has been used in a different sense, as will be shown hereafter, the expression cannot conveniently be applied in the case here considered. Nor can we use the phrase "possession in law;" for that, as above defined, is the owner's right to possess, that is, his present right to actual possession, which in the case here supposed, the owner has not. There appears then to be no one term, except possession simply, that can be used to express that kind of possession of land which a man has who has merely received rent from a lessee.

Possession, when coupled with the word estate, means a present right to possess. "An estate in possession gives a present right of present enjoyment;" "an estate in reversion gives a present right of future enjoyment." (Preston, 'Estates,' i. 89.) In this sense of possession, an estate in possession is opposed to an estate in remainder or reversion; but it does not imply actual possession. In the third section of the Act for the Limitations of Actions and Suits (3 & 4 Wm. IV., c. 27), an "estate or interest in possession" is opposed to an "estate or interest in reversion or remainder," and the actual possession of land is referred to in the same section by the terms "possession or receipt of the profits of the land." [STATUTE OF LIMITATIONS.]

A man is said to be *seised* of a freehold estate; but he is said to be *possessed* of a chattel real. The Statute of Uses does not apply to chattels real.

It remains to speak of a distinction in the word possession as applied to a real estate and a chattel personal. Both may be possessed, but the legal conclusion from the bare fact of possession is different in the case of a real estate and of a personal chattel. "There is a marked difference between a real estate and a personal chattel: the latter is held by possession; a real estate, by title. Possession of an estate is not even *primâ facie* title. It may be by lease only or from year to year." (Lord Eldon, Hiern *v.* Mill, 13 Ve., 114.) This seems to mean that, in the case of a chattel, possession is a presumption of ownership; but that possession of land is not; at least not a presumption of a freehold interest. Still it is so far a presumption of some interest, that if a man buys an estate from the owner, knowing that another man is in possession of it, he has notice of whatever interest the person in possession may have in the land; and therefore if the person in possession has a prior contract with the owner for purchasing the land, the second purchaser buys subject to the interest of the person in possession. (Daniels *v.* Davison, 16 Ve., 249; 17 Ve., 433.)

It has been already stated that *actual* possession of land, or what is legally considered actual possession, is necessary in order to give the owner all the advantages of ownership. In the case of chattels personal, ownership is frequently acquired without or rather before actual possession, and it may always be so acquired by contract when the thing agreed to be bought and sold is clearly determined. Sometimes the ownership can only be acquired together with the possession, because the thing only becomes determined by the act of delivery or taking possession. In all cases, however, when personal chattels are bought and sold, it is often a matter of great nicety to determine whether there has been possession by the purchaser, either as the condition or means of establishing his ownership, or for the purpose of ascertaining from what time a thing has ceased to be in one person's possession and come into the possession of another.

Questions as to this matter often arise in cases of loss, of insolvency of a vendee, &c., when the chattel is transferred from the vendor to the vendee by being *sent*, in which case it is of necessity during a certain time on its journey, or as our law expresses it, *in transitu*. The solution of questions of this kind, which often occur in a commercial country, is sometimes difficult, though many general principles are deducible from judicial decisions. The right of the vendor to stop the thing after it has commenced its journey, continues till the time at which the vendee is legally considered to have acquired possession. [STOPPAGE IN TRANSITU.]

It is remarked by Savigny ('Das Recht des Besitzes,' p. 185), "that in the whole theory of possession nothing seems easier to determine than the character of corporeal apprehension which is necessary to the acquisition of possession. By this fact all writers have understood an immediate touching of the corporeal thing, and have accordingly assumed that there are only two modes of apprehension: laying hold of a moveable thing with the hand; and entering with the foot on a piece of land. But as many cases occur in the Roman law in which possession is acquired by a corporeal act, without such immediate contact, these cases have been viewed as symbolical acts, which, through the medium of a juristical fiction, become the substitute for real apprehension." After showing that this is not the way in which the acquisition of possession is understood in the Roman law, and that there is no symbolical apprehension, but that the acquisition of possession may in all cases be referred to the same corporeal act, he determines what it is, in the following manner:

"A man who holds a piece of gold in his hand is doubtless the possessor of it; and from this and other similar cases has been abstracted the notion of a *corporeal contact generally* as the essential thing in all acquisition of possession. But in the case put, there is something else which is only accidentally united with this corporeal contact, namely, the physical possibility to operate immediately on the thing, and to exclude all others from doing so. That both these things concur in the case put, cannot be denied: that they are only accidentally connected with corporeal contact, follows from this, that the possibility can be imagined without the contact, and the contact without the possibility. As to the former case, he who can at any moment lay hold of a thing which lies before him, is doubtless as much uncontrolled master of it as if he actually had laid hold of it. As to the latter, he who is bound with cords has immediate contact with them, and yet one might rather affirm that he is possessed by than that he possesses them. This physical possibility then is that which as a fact must be contained in all acquisition of possession: corporeal contact is not contained in that notion, and there is no case in which a fictitious apprehension need be assumed."

This clear exposition of a principle of Roman law is applicable to all systems of jurisprudence which have received any careful elaboration, for the principle is in its nature general. It may be that the expounders of our law have not always clearly seen this principle, even when they have recognised it; and it may be that they have not always acted upon it. Still it appears from various cases that the physical possibility of operating on a thing is the essential character of the acquisition of possession in English law.

POSSIBLE and IMPOSSIBLE. The first of these words is of little interest, except as the contradictory of the second. The word *impossible* is used in common life to signify highly improbable, or utterly incredible. In this sense the impossible of yesterday is the possible of to-day. It is also used to signify that which would contradict the *laws of nature*, by which we always mean our view, knowledge, or experience of the laws of nature. In this sense also the impossible of yesterday is the possible of to-day. It was *impossible* that a missile should be thrown by the hand, and after traversing the air return to the hand again, until the boomerang of the savage found its way to the knowledge of the physical philosopher.

The true use of the word *impossible* is that which its etymology demands, that which *cannot be*. And how can we acquire the idea of that which *cannot be*, in the universe of an *omnipotent* Creator. On examination of the question, we arrive at no result but this, that all we can grasp of *impossibility* is *inconceivability*, and that every *thing* is conceivable which does not *contradict itself*, let it contradict what else it may. And thus (MATHEMATICS, col. 430) we arrive at the conclusion that nothing is impossible except that which contradicts the laws of thought, or the laws of the necessary matter of thought. Impossibility, then, is a word of logic and mathematics, and nothing else. It is impossible that "every X is Y" and "some XS are not YS," should both be true: it is impossible that two sides of a triangle should be less than the third.

But are we not, under this restriction, converting the *impossible* into the *possibly possible*? May there not be notions which though self-contradictory to *our* minds, are not so to minds of another stamp, or of a higher stamp. This question has been discussed before now: it has been asked *whether God could make two and two to be five*. In order to make this question intelligible, that is, to show that it is beyond intelligible answer, we must assert, without being able to go into full deduction, that every one of our impossibilities is resoluble into the idea of something which at once exists *and* does not exist. In the two and two which make five, there is an extra unit which *is* there and *is not*. When Euclid shows an impossibility he does it by showing that the notion requires a whole which is no greater than its part: so that the additional part which makes up the whole exists without existence. That is to say, in compassing an impossibility we start from this enunciation—

To be *and* not to be—that is the question.

Now when we are seriously asked—Is it in the power of the Creator to make the same thing to exist and not to exist at the same moment—we answer that our minds are so constructed that it looks very much as if we were *intended* to believe that it is *not*. And there we leave it: we would rather employ ourselves on the old question of the schoolmen,—which God loves best, a *possible* angel, or an *existing* fly.

But there is another point of view, from which the question might have been asked, and which perhaps lurked in the minds of those who first asked it. Can the Creator make two *and* two to be five?

The simplest mode of relation, that which we signify by *and*, gives four. But it is not beyond conceivability that a mind might be so constructed that its simplest operation should be different from ours. It would not cost Mr. Babbage an hour's thought to alter the fundamental structure of his difference-engine in such a manner that, instead of adding the two numbers presented, the machine should, of necessity, throw in an extra unit. That which man can execute, he can conceive the Creator performing on a larger scale: accordingly, it is within possibility that a mind should exist in which the simplest junction, to that mind, of two and two gives five, but the mode of junction would not be what we call *addition*.

The main purpose of such an article as the present is to bring forward the true meaning, in our laws of thought, of the word *impossible*; and to help the reader, should he need such help, to avoid importing the true meaning of the word into the phrases, "morally impossible," and "physically impossible." The word here used should be *incredible*. A confusion of this sort very frequently exists. The mind allows experience to fashion a *law of nature*, and postulates that the future shall agree with the past, and obey that law. This postulate once assumed, disobedience is an impossibility, *also assumed*: for simultaneous obedience and disobedience would be simultaneous existence and non-existence. But the question whether the law of nature, or what is assumed to be the law of nature, shall continue without exception for ever, cannot be argued upon the assumption that the settlement shall be of one preconcerted kind.

An eminent experimenter has laid down the following as his mode of proceeding: and that he does not intend the words *possible* and *impossible* to be used in their vague and popular sense is evident from his repeating the dictum, without remark or explanation, after full warning of what he seemed to be doing. "Before we proceed to consider any question involving physical principles, we should set out with *clear ideas* of the naturally possible and impossible." No doubt if there be a naturally possible and impossible, which is more than our experimenter can know, and if he can get a clear idea of it, which is more than he can do, his plan is a very good one. In the meanwhile, situated as we are in this world, we believe that a remark * made by Arago, a year before the above method was propounded, is much more to the purpose. It is that he who pronounces the word *impossible*, except in pure mathematics [to which logic ought to be added], shows a lack of prudence.

POST-OBIT BOND (*Post Obitum*, Lat.), a bond given for the purpose of securing a sum of money, the condition of which is, that the money shall be paid on the death of some person.

POST-OFFICE.—*History*. Correspondence is the offspring of advanced civilisation. When the state of society in this country anterior to the seventeenth century is considered, there can be little surprise that we hear nothing of a post-office before that period. Few of the motives to written communication could be said to exist. Each district of the country supplied its own wants. The little foreign trade which flourished was conducted between the English buyer and the foreign seller in person, at the port where the import was made. Literature and science dwelt only in the convent or the cell. There was little absence from the domestic hearth, excepting that of the fighting man following the service of his lord; but few, either servants or masters, had the power, even if they had the will, to write letters. The king summoned his barons from all quarters of the kingdom by letters, or writs, and held frequent communication with his sheriffs, to collect his parliament together, to muster his forces, to preserve his peace, to fill his treasury. The expenses of the establishment of Nuncii, charged with the conveyance of letters, formed a large item in the charges of the royal household. As early as the reign of King John, the payments to Nuncii for the carriage of letters may be found enrolled on the Close and Misæ-Rolls, and these payments may be traced in an almost unbroken series through the records of subsequent reigns. Nuncii also formed part of the establishment of the more powerful nobles. In a wardrobe account of the 27th year of Edward I., we find a specimen of the mode in which the payment is entered:—"x die Januarii nuncio Domini Regis de Hastang redeunti ad eundum dominum suum cum litteris Regis, pro expensis suis sic redeundo—xiii." As correspondence grew, it is easy to see that economical arrangements for its transmission would grow likewise. The Nuncius of the time of King John was probably obliged to provide his own horse throughout his journey; whilst in the reign of Edward II. he was able, and found it more suitable, to hire horses at fixed *posts* or stations. In 1481, Edward IV., during the Scottish war, is stated by Gale to have established at certain posts, twenty miles apart, a change of riders, who handed letters to one another, and by this means expedited them 200 miles in two days. It would seem that the posts, at which relays of riders and horses were kept, were wholly private enterprises; but that, when their importance became felt and appreciated, the state found it both politic and a source of profit to subject them to its surveillance. Before any substantive evidence appears of the superintendence of the posts by the government, the superscription often met with, of "haste poste haste," on letters written at the close of the fifteenth and beginning of the sixteenth centuries, is sufficient to show that the posts had become the customary channel for transmitting letters in the speediest way.

A statute in 1548 (2 and 3 Edw. VI., c. 3) fixed a penny a mile as the rate to be chargeable for the hire of post-horses. In 1581, one Thomas Randolph is mentioned by Camden as the chief postmaster of England; and there are reasons for concluding that his duties were to superintend the posts, and had no immediate connection with letters. The earliest recital of the duties and privileges of a postmaster seems to have been made by James I. The letters patent of Charles I., in 1632 ('Pat.,' 8 Car. I. p. i. m. 15 d; 'Fœdera,' vol. 19, p. 385) recite that James constituted an office called the office of postmaster of England for foreign parts being out of his dominions. This functionary was to have "the sole taking up, sending, and conveying of all packets and letters concerning his service, or business to be despatched into forraigne parts, with power to grant moderate salaries;" the office was "graunted to Mathewe le Quester, and Mathewe le Quester his son: all others were publiquely prohibited that they should not directly or indirectly exercise or intrude themselves: the said M. le Quester made and substituted William Frizell and Thomas Witherings his deputies, and his Majesty accepted the substitution." The king, "affecting the welfare of his people, and taking into his princely consideration how much it imports his state and this realm that the secrets thereof be not disclosed to forreigne nations, which cannot be prevented if a promiscuous use of transmitting or taking up of forreigne letters and packetts should be suffered," forbids all others from exercising that which to the office of such postmaster pertaineth, at their utmost perils.

In 1635, a proclamation was made "for settling of the letter-office of England and Scotland." It sets forth "that there hath been no certain or constant intercourse between the kingdoms of England and Scotland;" and commands "Thomas Witherings, Esq., his Majesty's postmaster of England for foreign parts, to settle a running post or two, to run night and day between Edinburgh and Scotland and the City of London, to go thither and come back in six days." Directions are given for the management of the correspondence between post-towns on the line of road, and other towns which are named, and likewise in Ireland. All postmasters are commanded "to have ready in their stables one or two horses:" 2½*d.* for a single horse, and 5*d.* for two horses per mile were the charges settled for this service. A monopoly was established, with the exceptions in favour of common known carriers and particular messengers sent on purpose, most of which have been preserved in all subsequent regulations of the Post-Office. In 1640, a proclamation was made concerning the sequestration of the office of postmaster for foreign parts, and also of the letter-office of England, into the hands of Philip Burlamachy, of London, merchant; but, in 1642, it was resolved by a committee of the House of Commons, that such sequestration was "a grievance and illegal, and ought to be taken off," and that Mr. Wytherings ought to be restored. As late as 1644, it appears that the postmaster's duties were not connected directly with letters. A parliamentary resolution entered on the Journals of the Commons states that, "the Lords and Commons, finding by experience that it is most necessary, for keeping of good intelligence between the parliament and their forces, that post stages should be erected in several parts of the kingdom, and the office of master of the posts and couriers being at present void, ordain that Edmund Prideaux, Esq., a member of the House of Commons, shall be, and is hereby constituted, master of the posts, messengers, and couriers." "He first established a weekly conveyance of letters into all parts of the nation, thereby saving to the public the charge of maintaining postmasters to the amount of 7,000*l.* per annum." (Blackstone.) An attempt of the Common Council of London to set up a separate Post-Office, in 1649, was checked by a resolution of the House of Commons, which declared "that the office of postmaster is, and ought to be, in the sole power and disposal of parliament."

But the most complete step in the establishment of a Post-Office was taken in 1656, when an act was passed "to settle the postage of England, Scotland, and Ireland." This having been the model of all subsequent measures, induces us to give something more than a passing notice of it. The preamble sets forth "that the erecting of one general Post-Office for the speedy conveying and recarrying of letters by post to and from all places within England, Scotland, and Ireland, and into several parts beyond the seas, hath been and is the best means not only to maintain a certain and constant intercourse of trade and commerce between all the said places, to the great benefit of the people of these nations, but also to convey the publique despatches, and to discover and prevent many dangerous and wicked designs which have been, and are, daily contrived against the peace and welfare of this commonwealth, the intelligence whereof cannot well be communicated but by letter of escript." It also enacted that, "there shall be one Generall Post-Office, and one officer stiled the postmaster-generall of England and comptroller of the Post-Office." This officer was to have the horsing of all "through" posts and persons "riding in post." Prices for letters, whether English, Scotch, Irish, or foreign, and for post-horses, were fixed. All other persons were forbidden to "set up or imploy any foot-posts, horse-posts, or pacquet-boats." These arrangements were confirmed in the first year of the Restoration, by an act which was repealed 9 Anne, c. 11. In 1683, a metropolitan penny-post was set up, the history of which is given at length in the 'Ninth Report of the Commissioners of Post-Office Inquiry.' From 1711 to 1838, upwards of 150 acts affecting the regulations of the Post-Office were passed. In the first year of her present Majesty, ninety-nine of these were repealed, either wholly or partially, and the following acts were passed, by which the whole department of the Post-Office was regulated:—

For the management of the Post-Office, c. 33.

The regulation of the duties of postage, c. 34.

For regulating the sending and receiving of letters and packets by the post, free from the duty of postage, c. 35.

For consolidating the laws relative to offences against the Post-Office, and explaining certain terms and expressions, c. 36.

A mere enumeration of the titles of all the acts affecting the Post-Office would occupy a considerable space. An account even of these four last-mentioned acts must be dispensed with, and the reader referred to the acts themselves. Their enactments have been abrogated, to a great extent, by the adoption of Mr. Rowland Hill's plan of uniform postage, which we shall notice hereafter. This measure was carried into effect by an act passed in 1839, 2 & 3 Vic. cap. 52, which conferred temporary powers on the Lords of the Treasury to do so, and was subsequently confirmed by an act 3 & 4 Vic., c. 96, passed 10th August, 1840.

Rates of Postage.—The first establishment of a rate of postage for carrying letters occurs in 1635, in the proclamation already described. The rates were fixed as follows :—

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* Celui qui, en dehors des mathématiques pures, prononce le mot *impossible*, manque de prudence. ('Annuaire' for 1853, p. 445.)

Under 80 miles	2*d.* single letter.
Between 80 miles and 140 miles . . .	4 "
Above 140 miles	6 "
On the borders and in Scotland . . .	8 "

"Two, three, four, or five letters in one packet, or more, to pay according to the bigness of the said packet."

The rates, both inland and foreign, fixed by the ordinance of the Commonwealth in 1656, are therein fully detailed. Letters above two sheets were charged by weight. In most cases, the rates vary but little from those fixed in the 12 Car. I., the principal of which were as follows :—

Letter not exceeding one sheet, to or from any place not exceeding 80 miles, 2*d.*; above 80 miles, 3*d.* From London to Berwick, 3*d.*; to Dublin, 6*d.* Letters of two sheets were charged double. By the 9 Anne, c. 11, a penny was added to several of the rates previously established; a letter from London to Edinburgh was charged 6*d.* Additions were subsequently made; but the principle of the rating was to charge according to the distance which the conveyance travelled, until the year 1839, when the direct distance only was charged. A single letter was interpreted to mean a single piece of paper, provided it did not exceed an ounce in weight. A second piece of paper, however small, or any inclosure, constituted a double letter. A single sheet above an ounce was charged with fourfold postage. After a fourfold charge, the additional charges advanced by weight.

In Scotland, letters, when conveyed by mail-coaches only, were subject to an additional halfpenny. Letters passing between Great Britain and Ireland were subject to the rates of postage charged in Great Britain, besides packet rates, and Menai, Conway Bridge, or Milford rates.

Between 1814 and 1839, the rates in Ireland were as follows :—

Distances in Irish Miles.	Rates for Single Letters.	Distances in Irish Miles.	Rates for Single Letters.
7	2*d.*	95	9*d.*
15	3	120	10
25	4	150	11
35	5	200	12
45	6	250	13
55	7	300	14
65	8		

The postmaster-general had authority to establish penny posts for letters not exceeding in weight four ounces, in, from, or to, any city, town, or place in the United Kingdom (other than London or Dublin), without any reference to the distance to which the letters are conveyed.

The principle which guided the department in establishing penny posts was, to select small towns and populous neighbourhoods, not situated in the direct lines of general-post conveyances, and desirous of obtaining that facility, wherever such penny post did not afford the means of evading the general post, and promised to yield a return that would pay for its maintenance. The rule was to consider whether the receipts on the first setting up of the post would pay about two-thirds of the charge. The Post-Office took its chance of the remainder being made good.

The London Twopenny Post extended to all letters transmitted by the said post in the limits of a circle of three miles' radius, the centre being the General Post-Office in St. Martin's-le-Grand, which limits the postmaster-general had authority to alter. The London Threepenny Post extended to all letters transmitted by the said post beyond the circle of three miles' radius, and within the limits of a circle of twelve miles' radius, the centre being the General Post-Office.

The select committee of the House of Commons, in 1838 and 1839, which investigated Mr. Rowland Hill's plan, reported the following to be the average rates of postage :—

AVERAGE RATES, MULTIPLE LETTERS BEING INCLUDED AND COUNTED AS SINGLE.

	d.	*d.*
Packet and ship letters	23·1562	= nearly 23¼
Ditto, and inland general-post letters . .	9·7065	= nearly 9¾
Ditto, ditto, and London 2*d.* and 3*d.* post letters	8·4066	= nearly 8½
Ditto, ditto, ditto, and country 1*d.* post letters	7·6074	= little more than 7½
Inland general-post letters only . . .	8·6502	= nearly 8¾
Ditto, and London 2*d.* and 3*d.* post letters . .	7·4688	= nearly 7½
Ditto, ditto, and country 1*d.* post letters .	6·7414	= nearly 6¾

AVERAGE RATES, MULTIPLE LETTERS BEING EXCLUDED.

Single inland general-post letters . . .	7·7445	= nearly 7¾
Ditto, and London 2*d.* and 3*d.* post letters .	6·8202	= little more than 6¾
Ditto, ditto, and country 1*d.* post letters . .	6·2166	= nearly 6¼

Franking.—As early as a post-office was established, certain exemptions from the rates of postage were made. Parliamentary franking existed in 1666. An entry is registered on the Journals of the House of Commons on 19th October 1666, "That Edward Roberts be sent for in custody of the serjeant-at-arms, or his deputy, to answer his abuse and breach of privilege in exacting money of the members of this House for post-letters." In the paper bill which granted the Post-office revenue to Charles II., a clause provided that all the members of the House of Commons should have their letters free, which clause was left out by the Lords, because no similar provision was made for the passing of their letters; but a compromise was made on the assurance that their letters should pass free.

In 1785 the House of Commons prosecuted some investigations into the subject, which appear on the Journals. Again, in 1764 (4 Geo. III.), a committee was appointed "to inquire into the several frauds and abuses in relation to the sending or receiving of letters and parcels free from the duty of postage." Among various abuses proved to exist, it is related that "one man had in the course of five months counterfeited 1200 dozen of franks of members of parliament, and that a regular trade of buying and selling franks had been actually established with several persons in the country." Resolutions restricting and regulating the privilege were passed. From time to time the privilege was extended, until it was finally abolished, with a very few exceptions, on 10th January, 1840.

Seven millions of franks, out of sixty-three millions of general-post letters, including franks, were estimated in 1838 to pass through the Post-Office annually. The relative quantities of these several documents are given in the 'Third Report of the Commons' Committee,' as follows :—

				Single Letters.
56,000,000	of general-post chargeable letters, equivalent at	1⅛	to	63,000,000
4,813,448	parliamentary franks . . .	2	to	9,626,896
2,109,010	official franks	8	to	16,872,080
77,542	copies of the statutes . . .	13	to	1,008,046
63,000,000				90,507,022

The privileged letters, therefore, reduced to the standard of single letters, amounted to above 30 per cent. of the whole number of letters transmitted by the general post.

The average weight of a single chargeable letter was about 3-10ths of an ounce; the average weight of a parliamentary frank about 48-100ths of an ounce; that of an official frank, 1·9376 oz., or nearly two ounces; and that of a copy of a public statute, 3·1129 oz. Had they been liable to the then existing rates, they would have contributed in the following proportions to the revenue :—

	Number.	Rate per Letter.	Revenue.
		d.	£
Parliamentary franks .	4,813,448	17·393	348,814
Official franks . . .	2,109,010	70·209	616,965
Statutes distributed .	77,542	112·795	36,443
Totals . . .	7,000,000	....	1,002,222

Newspapers, with a few exceptions, passed free of postage. All franking is now altogether abolished, except petitions forwarded to peers and members of parliament.

Revenue.—The statistics of the Post-Office revenue are far from complete. In the early period of the Post-Office establishment, and before 1716, only a few scattered accounts can be collected. In 1653 the annual revenue was farmed for 10,000*l.*, and in 1659 for 14,000*l.* (Journals of the Commons.) In 1663 it was farmed for 21,500*l.* annually, and the amount settled on the Duke of York. In 1674 the farming of the revenue yielded 43,000*l.* In 1685 it produced 65,000*l.* Parliament resumed the grant after 1688, though the king continued to receive the revenue. In 1711 the gross revenue was reckoned at 111,426*l.* From 1716 to 1733 the average yearly net revenue was 97,540*l.*, founded upon "a certain account, and not an estimate." (Commons Journals, April 16, 1735.) In the Postage Reports of 1838 (vol. ii., App., p. 176; vol. i., p. 511) are accounts showing the gross receipt, charge of management, net receipt, and rate per cent. of collection in Great Britain from 1758 to 1837, and in Scotland and Ireland from 1800 to 1837. The accounts for a few years will serve to show its progress :—

GREAT BRITAIN.

Years ended April 5.	Gross Receipts.	Charges of Management.	Net Receipt (returns deducted).	Rate per cent. of Collection.
	£	£	£	£ s. d.
1758	222,075	148,345	73,730	66 15 11
1769	305,058	140,298	164,760	45 19 9
1779	402,918	263,670	139,248	65 8 9
1786	506,500	220,525	285,975	43 10 9
1799	1,012,731	324,787	657,388	32 1 4
1816	2,193,741	594,045	1,526,527	27 1 6
1837	2,206,736	609,220	1,511,026	27 12 1

SCOTLAND.

Years.	Gross Receipts.	Charges of Collection.	Net Income.	Rate per cent. of Collection.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1800	100,651 14 4	16,896 8 0	83,755 6 4	16 15 0
1837	220,758 13 10	59,945 7 1	[illegible],818 6 9	27 0 0

IRELAND.

Years.	Gross Receipts.	Charges of Collection.	Net Receipt (Returns deducted).	Rate per cent. of Collection.		
	£	£	£	£	s.	d.
1800	84,040	59,216	24,824	70	9	2
1837	255,070	95,548	134,809	37	9	2

The revenue for the United Kingdom for the years ended January 5, 1838 and 1839, was as follows :—

Years ended Jan 5.	Gross Receipts.	Charges of Collection.	Returns.	Net Receipts.	Rate per cent. of Collection.		
	£	£	£	£	£	s.	d.
1838	2,462,269	669,940	122,531	1,669,798	27	4	1
1839	2,467,216	669,756	120,938	1,676,522	27	2	11

The Select Committee on Postage, in 1838, instituted the following comparison between the Post-Office revenue of the six years ending 5th January, 1838, and that of six years ending 5th January, 1821 :—

	Gross Revenue, excluding Repayments.		Net Revenue, after deducting cost of Management.	
See Appendix to Report I., p. 509.	1815 to 1820 inclusive.	1832 to 1837 inclusive.	1815 to 1820 inclusive.	1832 to 1837 inclusive.
	£	£	£	£
	2,273,843	2,175,292	1,598,295	1,581,828
	2,323,835	2,190,181	1,619,196	1,553,425
	2,186,634	2,209,439	1,537,505	1,513,052
	2,099,225	2,243,294	1,433,871	1,564,458
	2,151,213	2,350,608	1,467,533	1,645,835
	2,108,833	2,339,738	1,522,640	1,658,479
Totals of the six years	13,143,583	13,508,547	9,179,040	9,467,077
Average of the six years	2,190,597	2,251,424	1,529,840	1,577,846
Increase at the end of seventeen years	60,827	..	48,006	..
Annual average increase	3,578	..	2,823	..

It thus appeared that on an average gross revenue of 2,190,597*l.* there had been in seventeen years a positive increase of 60,827*l.*, averaging only 3578*l.* yearly, or little more than 1½ per thousand, though the advance had been rapid in population, and still more so in wealth, industry, and trade.

Establishment, Cost of Management, &c.—The head of the Post-Office is styled the Postmaster-General, under whose authority are placed all the post-offices in the United Kingdom and the colonies. The office was formerly held by two persons. It is considered a political one, and the holder relinquishes it with a change of ministry. The Commissioners of Post-Office Inquiry (4th Report) recommended that the office should be exercised by three permanent commissioners; and a bill passed the Commons to give effect to the recommendation, but was thrown out by the Lords.

In 1831 and 1832 the chief offices of London, Dublin, and Edinburgh were remodelled by the Duke of Richmond, then postmaster-general. The separate office of postmaster-general for Ireland was abolished, and other changes were made, which were estimated to reduce the expenses above 4700*l.* per annum. In London the saving was estimated at 6448*l.* per annum: a secretary at Dublin and at Edinburgh is chief executive officer for the respective countries.

The metropolitan General Post-Office was removed in 1829 from Lombard Street to St. Martin's-le-Grand. It is the head-quarters of all post-office business. All accounts of the collection of the revenue and the expenditure are rendered there.

No accounts of the number of documents passing through the Post-Office were kept until shortly before the introduction of Sir Rowland Hill's system. Founded upon a very careful examination of the best data, the numbers, the result of very elaborate calculations, are appended to the 'Report of the Commons' Committee;' as here subjoined :—

Description of Letters.	Yearly Number of Letters.	Average rate per Letter.	Yearly Revenue.
		d.	£
Packet and ship letters	3,523,572	23·1562	369,340
General-post inland letters above 4*d.*	46,378,800	9·2224	1,782,191
Ditto, not exceeding 4*d.*	5,153,200	3·5	75,151
London local-post letters	11,837,852	2·3266	114,753
Country penny-post letters	8,030,412	1	33,483
Total	74,923,836	7·6074	2,374,923
Parliamentary franks	4,813,448	..	..
Official franks, for public purposes	2,109,010	..	..
Public statutes	77,542	..	..
Newspapers	44,500,000	..	..
Total of documents transmitted by post	126,423,836	..	2,374,923
Unappropriated			4,641
Total revenue from letters, 1837			2,379,564

See Notes to 'Postage Report,' pages 4 and 6.

The chargeable letters in the mails leaving London were found to weigh only 7 per cent. of the whole weight of those mails. The total weight of the chargeable letters and franks carried by the thirty-two mails leaving London was only 2912 lbs. Deducting one-half as the weight of the franks and franked documents, the weight of all the chargeable letters was only 1456 lbs., being 224 lbs. less than the weight which a single mail is able to carry.

The management of the conveyance of the mails by sea and land was subject, of course, to those constant changes which arise out of the improvements daily taking place in the various modes of transit. Certain packets were exclusively controlled by the Admiralty, to whose charge they were removed in 1837; others remained with the Post-Office; but the whole are now placed under the Post-Office management. The parliamentary returns and reports of various commissioners on the subject of the packet-service are numerous. The most important are—'The Twenty-second Report of the Commissioners of Revenue Inquiry,' part 5, printed 1830, and the 'Sixth Report of the Post-Office Commissioners on the Packet Establishments,' printed in 1836. Contracts for the conveyance of the mail-bags to the Continent are made between the Post-Office and the proprietors of certain steam-vessels. The Post-Office moreover has power of sending a bag of letters in any private ship.

The inland correspondence is carried by railroads, by four-horse and two-horse coaches; by cars in Ireland, by single-horse carts, on horseback, and foot.

The number of miles travelled over in England and Scotland by the mail-coaches in the following years, was as follows :—

1834	5,911,006	1837	6,643,217
1835	5,931,218	1838	7,204,295
1836	6,233,476	1839	7,377,857

And a parliamentary return, printed 1836 (No. 364), presented the following account of the speed and cost of the mail-coaches :—

	England. Miles.	Ireland. Miles.	Scotland. Miles.
Greatest speed travelled per hour	$10\frac{5}{8}$	$9\frac{1}{8}$	$10\frac{1}{2}$
Slowest	6	$6\frac{7}{8}$	7
Average speed	$8\frac{7}{8}$	8	$8\frac{3}{4}$

The system of mail-coaches owes its origin to Mr. Palmer. In 1784, Mr. Palmer, who was manager of the Bath and Bristol theatres, laid a plan before Mr. Pitt, which was adopted by the government, after much opposition from the functionaries in the Post-Office. The greatest improvement in the transmission of the correspondence of the country was effected by this plan. Mr. Palmer found the post, instead of being the quickest, nearly the slowest conveyance in the country; very considerably slower than the common stage coaches. The average rate of speed did not exceed three miles and a half per hour. Whilst coaches left London in the afternoon and reached Bath on the following morning, the post did not arrive till the second afternoon. Slowness was not the only defect: it was also irregular, and very insecure. The robbery of the mail was very common. Mr. Palmer succeeded in perfecting the mail-coach system, and in greatly increasing the punctuality, the speed, and security of the post. At least 500 places obtained a daily delivery of letters, which before received them not oftener than three times in the week.

The net revenue before these changes had averaged for twenty years about 150,000*l.* a year. In ten years after Mr. Palmer's plan had been in work, the net revenue increased to 400,000*l.*; in twenty years it became 700,000*l.*; and in thirty years it had reached a million and a half, from which sum it can hardly be said to have advanced to the time of the adoption of Sir Rowland Hill's system. The reader will find both the history and progress of Mr. Palmer's plan, of the Post-Office opposition, and the subsequent proceedings arising out of his claims, fully related in parliamentary papers, printed by order of the House of Commons in 1807, 1808, and 1813.

In 1838 a plan calculated not only to increase the utility of the Post-Office in the promotion of all the objects of civilisation, but to change the whole management of the institution, was brought forward by Mr. (now Sir) Rowland Hill, a gentleman wholly unconnected with the department. It was at first privately submitted to the government, and subsequently published in a pamphlet under the title of 'Post-Office Reform—its Importance and Practicability.' In a short period three editions were issued. The main features of Mr. Hill's plan, which putting aside the merits of the suggestion of a uniform rate, is discussed with singular moderation, acuteness, caution, and sound reasoning, proposed to effect—1, a great diminution in the rates of postage; 2, increased speed in the delivery of letters; and, 3, more frequent opportunities for their despatch. He proposed that the rate of postage should be uniform, to be charged according to weight, and that the payment should be made in advance. The means of doing so by stamps were not suggested in the first edition of the pamphlet, and Mr. Hill states that this idea did not originate with him. A uniform rate of a penny was to be charged for every letter not exceeding half an ounce in weight, with an additional penny for each additional ounce. Mr. Hill discovered the justness and propriety of a uniform rate in the fact that the cost attendant on the transmission of letters was not measured by the distance they were carried. He showed on indisputable data that the actual cost of conveying letters from

London to Edinburgh, when divided among the letters actually carried, did not exceed one penny for thirty-six letters. Independently of its fairness, the obvious advantages of simplicity and economical management were strongly in favour of a uniform rate.

The publication of this plan immediately excited a strong public sympathy in its favour, and especially with the commercial classes of the city of London. Mr. Wallace moved for a select committee to inquire into its merits on the 9th May, 1837; but the motion fell to the ground. On the 30th May, 1837, Lord Ashburton, upon presenting a petition from some of the most eminent merchants, bankers, men of science, and others in the metropolis, to the House of Lords, spoke strongly in favour of the plan. In the December of the same year the government assented to the appointment of a select committee to inquire into and report upon the plan. A society of merchants was forthwith formed in the city of London to furnish evidence of the evils of the high rates of postage, and the insufficiency of the Post-Office management in answering the wants of the present times. The subject began to excite much interest throughout the country. In the session of 1837 five petitions were presented to the House of Commons in favour of the plan. In 1838 upwards of 320 were presented, of which number seventy-three emanated from town councils, and nineteen from chambers of commerce. After sitting upwards of sixty-three days, and examining Mr. Rowland Hill and eighty-three witnesses, besides the officers of the departments of the Post-Office and the Excise and Stamp offices, the committee presented a most elaborate report in favour of the whole plan, confirming by authentic and official data the conclusions which Mr. Hill had formed from very scanty and imperfect materials.

The appearance of the committee's report seemed to inspire the whole country with confidence in the plan. Petitions in its favour amounting to 2000 were presented to both houses of parliament in the session of 1839. The Duke of Richmond, then postmaster-general, advised the government to adopt it; and the chancellor of the exchequer brought forward a bill to enable the Treasury to carry the plan into effect, which was carried by a majority of one hundred in the House of Commons, and passed into law on the 17th August, 1839. In the following month an arrangement was made which secured Mr. Rowland Hill's superintendence of the working out his own measure. On the 5th December, 1839, as a preparatory measure, to accustom the department to the mode of charging by weight, the inland rates were reduced to an uniform charge of 4*d.* per half ounce. The scale of weight for letters advanced at a single rate for each half ounce up to sixteen ounces. Other reductions were made in the packet-rates; and the London district post was reduced from 2*d.* and 3*d.* to 1*d.* This measure continued in force until the 10th January, 1840, when a uniform inland rate of postage of 1*d.* per half ounce, payable in advance, or 2*d.* payable on delivery, came into operation. On this day parliamentary franking entirely ceased. On the 6th May stamps were introduced. The warrants of the lords of the Treasury which authorised these changes were published in the London Gazette of the 22nd November, 28th December, 1839; 25th April, 1840.

The first entire year of the penny postage was 1840, but then letters might be paid, or stamped, or were charged double. In that year 191,931,365 letters passed through the post-offices of the United Kingdom. The revenue derived from the Post-Office had been 1,649,088*l.* in 1839; in 1840 it only amounted to 495,514*l.* In 1845 the number of letters had reached 329,161,811, and the revenue 760,588*l.* The number of letters and the amount of net revenue continued to increase rapidly. In 1848 the additional advantage was given of a book-post, by which single books could be sent, open at the ends, at an uniform rate of 6*d.* per pound. This privilege was gradually extended to the British colonies. In 1855 the rate of postage for printed sheets was reduced to 1*d.* for a quarter of a pound, 2*d.* for half a pound, and 2*d.* extra for each fraction above half a pound; but if 4*d.* or upwards were paid, the packet might contain any number of sheets written or printed, except that the writing must not be of the nature of a letter. The last regulation issued in 1857 is that the packet may contain, in every case, any number of sheets, written or printed, but the written matter must not be of the nature of a letter, and may consist of bound books, or maps or prints on rollers, or whatever is necessary to the safe transmission of literary or artistic matter, such packets, however, not to exceed two feet in length, depth, or width, and all must be open at the ends or sides. Such packets may also be sent to all the British colonies at the rate of 3*d.* for 4 oz., 6*d.* for 8 oz., and then proceeding at the rate of 6*d.* for every 8 oz., or portion thereof, except to Ascension Island, the East Indies, Hong Kong, Australia, New Zealand, and the Gold Coast, to all of which the rates are one-third more, and the weight is restricted to three pounds. By various conventions the foreign postage of letters has been materially reduced, in some cases 50 per cent., and in others varying from 17 to 20 per cent. The rates to all the British colonies were in 1857 reduced to an uniform rate of 6*d.* per half-ounce, payable in advance.

The sixth annual return of the Post-Office for 1859 states that the total number of letters delivered in the year was 545,000,000, of which 446,000,000 were in England and Wales, 47,000,000 in Ireland, and 52,000,000 in Scotland. These numbers give an average, in England, of 22 letters for each person of the population (in London it amounts to 43 for each), in Ireland of 7 for each, and in Scotland of 16 for each person. The number of newspapers passing through the Post-Office was 70,500,000, more than half of which bore the newspaper stamp. The number of book-packets was about 11,000,000. There were 470,000 newspapers, and 1,900,000 letters that from various causes could not be delivered, chiefly from illegible or erroneous directions. The gross revenue (including the produce of the impressed stamps on newspapers, received by the Inland Revenue Office) was 3,448,074*l.*; the cost of management, 2,312,114*l.* (including 444,519*l.* for mail-packets, defrayed by the Admiralty, but fairly chargeable to the Post-Office), which, added to the net revenue, 1,135,960*l.*, equals the revenue derived from the Post-Office in 1838; while the number of letters delivered has increased by 460,000,000. The cost of management includes the following items:—Salaries, pensions, &c., 1,037,525*l.*; buildings, 32,081*l.*; conveyance of mails by railways, 446,000*l.*; by coaches, carts, &c., and wages of mail-guards, 168,507*l.*; by mail-packets (when paid for by the Post-Office) and private ships, 5454*l.*; for manufacture of postage-stamps, 25,940*l.*; miscellaneous, including conveyance of mails in the colonies, under the postal direction of the postmaster-general, the conveyance of the mails through Egypt, clothing for letter-carriers and guards, rents, taxes, law expenses, &c., 138,446*l.*

In November, 1840, a most important improvement was introduced by an increased facility in transmitting small sums of money. The Post-Office had been accustomed to give orders on local post-offices for sums under 5*l.* 5*s.*, for which they charged 5 per cent.; and as the order was on a separate sheet, it involved double postage. The order was next given on a sheet of letter-paper, which saved a postage; later, the charge was reduced to a fixed sum of 1*s.* 6*d.* for sums between 2*l.* and 5*l.*, and 6*d.* for sums less than 2*l.* These charges were reduced to 6*d.* and 3*d.* respectively: the effect was prodigious. In the three months ending Feb. 5, 1841, the amount paid on such orders was 59,432*l.*, against 8141*l.* in the corresponding months of 1840. For some time, however, the expenses of the Money-Order Office, for which a distinct staff had to be organised, exceeded the profits. But the increase of business has been continuous, and money-orders are now the source of a large revenue, except in Ireland. In 1859 the total number of money-orders issued in the United Kingdom was 6,969,108, to the amount of 13,250,930*l.*, an increase of 4¾ per cent. over 1858. Of the total number, 5,932,133 orders, to the amount of 11,358,057*l.*, were issued in England; 498,828, to the amount of 891,675*l.*, in Ireland; and 538,147, to the amount of 1,001,298*l.*, in Scotland. The commission gave a profit, after deducting expenses, in England, of 27,780*l.*, and in Scotland of 2019*l.*; in Ireland there was a loss of 684*l.* The number of orders gives an average of 1 for every 3 persons in England, for every 6 in Scotland, and for every 13 in Ireland. Money-order offices have also been established at Malta, Gibraltar, and in Canada.

In 1855 some important improvements in matters of detail were introduced with great success. Country letters to London, or passing through London, were either sorted at the provincial offices or during their transmission, and this expedited the morning delivery in London by nearly an hour. Pillar letter-boxes were also erected in London, Edinburgh, and Dublin; they have been since extended to most considerable places in the United Kingdom. In 1859 there were 825 head offices, 10,587 sub-offices, and 1958 road letter-boxes; a total of 13,370 public receptacles for letters, against 4518 before the establishment of the penny postage. London was also divided into 10 districts, each having a district head-office, by which letters posted in a district for a neighbouring place are spared the loss of time incurred by transmission to the chief office, and thus a more speedy delivery is attained; and this division also greatly facilitates the sorting of inland letters; but to effect this, the initial letters of East Central, West Central, North, East, South, West, North East, North West, South East, and South West, must be distinctly placed at the end of the direction after "London." A book, price one penny, has been published, distinguishing all the streets and places within the different districts.

Nearly every town of any size throughout the three kingdoms has at least two deliveries a day from and to its metropolis and the larger provincial towns. In 1859 there were 77 such towns added to the list. In the same year the mails within the United Kingdom were conveyed daily over 140,321 miles of way; of this, 35,604 miles are by railway, at an average rate of 9¼*d.* a mile; 32,936 by coaches, mail-carts, &c., at an average of 2¼*d.* a mile; 68,964 by carriers on foot, at an average rate of 1¼*d.* a mile; and 2817 miles by packets and boats between different places in the United Kingdom, at rates varying from 5*s.* 6¼*d.* a mile to ¼*d.*

The total number of persons engaged in the service of the Post-Office for the United Kingdom was 24,802, on December 31, 1859, including 1 postmaster-general; 5 secretaries, assistant secretaries, and secretaries for Ireland and Scotland; 15 surveyors; 18 other superior officers, such as heads of departments, chief clerks in the metropolitan offices, &c.; 11,235 postmasters; 1632 clerks (exclusive of some employed temporarily); 197 guards; 11,076 letter-carriers, messengers, &c.; 7 marine officers; 125 postmasters, clerks, &c., in the colonies; and 61 agents in foreign countries. Of this number about 2000 are attached to the London staff, and (including this number) about 3300 are employed in the London district.

The third annual report of the postmaster-general for 1856, in an appendix, states that "in no part of the United Kingdom has more been done for the welfare of the people by the use of railways for carrying mails and by the penny postage system than in Ireland." In 1784 there were posts six days a week on only four lines of road; letters to all other places being conveyed only twice or thrice a week. Now there are daily posts to almost every village, and there is but one important town that has not two daily mails both with London and Dublin. In 1784 the whole expense of the office in Ireland was 15,000*l.*, including salaries of provincial postmasters and the conveyance of mails. Out of this sum, 5500*l.* only was allotted to the provinces; the sum allotted in 1856 for the like service was 134,000*l.*, divided thus:—conveyance of mails by railways, 65,505*l.*; by coaches and cars, 27,168*l.*; by foot-messengers, 10,334*l.*; and salaries and wages paid in provincial offices, 31,122*l.* In 1829 the cost of conveying the mail by mail-coaches was nearly four times the average rate of England; this excess has now disappeared, and in 1859 the average rate per mile was for England 2½*d.*, for Scotland 2¾*d.*, and for Ireland 2*d.*

The same paper pays a just tribute to the exertions of Mr. Bianconi for the improvement of intercommunication in Ireland, particularly in reference to the transmission of letters.

The amount of postage collected at different towns in the United Kingdom (including the postage-stamps sold by the Post-Office and by the Board of Inland Revenue) shows some curious results. London, of course, through which passes nearly one-half of the total correspondence of the kingdom, attains a great predominance, the amount in 1857 being 833,952*l.*; Liverpool, with 255,000 inhabitants, contributed 104,865*l.*; while Manchester, with 316,000 inhabitants, only contributed 89,765*l.*; and Birmingham, with 232,000 inhabitants, but 42,107*l.* Bristol, with about 100,000 inhabitants (including Bedminster), furnished 31,264*l.*; Leeds, with 172,000 inhabitants, only 23,844*l.*; and Sheffield, with 135,000 inhabitants, no more than 16,565*l.* In Ireland the contributions were more in accordance with the size of the towns: Dublin contributed 60,391*l.*; Belfast, 15,547*l.*; Cork, 11,915*l.*; and Limerick, 7115*l.* In Scotland:—Edinburgh, with 160,000 inhabitants, contributed 59,177*l.*; and Glasgow, with 358,000 inhabitants, only 68,877*l.* It must be recollected, however, that in many cases some towns are used as a sort of depôt, from whence postage-stamps are distributed over a wider district than others.

POSTING, from the French "poste," derived from the Low Latin word "posta" (Ducange, *in verbo*), is so called from horses being placed at certain stations or posts, where they may be hired by individuals at their pleasure. The application of the words "post" and "postmaster" as well to the transmission of letters and the persons to whom this business is entrusted, as to stations where post-horses are kept, and the persons who own or have the care of them, is the cause of much confusion: and it frequently cannot be understood in reference to which branch early writers intend these terms to be applied. The ambiguity is not confined to the English language. Post-horses were first established by the governments on the continent of Europe in the 13th and 14th centuries for the conveyance of despatches; they were occasionally employed for the conveyance of persons connected with such governments, and gradually by passengers in general. Posting continues in most countries to be carried on by the state, which retains the monopoly of supplying post-horses, and usually of forwarding mails and diligences. The prices are fixed by the governments, as well as the number of horses that must be employed, according to the weight or number of persons to be conveyed, or even by the state of the roads. In the United States and British North America there is at present (1859) no posting, at least in the sense in which the term is commonly used; that is to say, a person cannot have his carriage conveyed in such a direction as he may wish, and hire fresh horses at convenient stages. He must engage an "extra exclusive" in some principal town, and the same horses must convey him throughout his whole journey, unless another large town should lie on the road. This is the mode of travelling known on the Continent by the name of "vetturino," "voiturier," or "Lohnkutscher." The want of the power of posting is not so inconvenient as might be supposed, for the number of private carriages is not large, and in districts where there is much travelling, communication is usually facilitated by steam-boats, railways, and stage-coaches.

Posting is very generally established in England, but is now less used in consequence of the introduction of railways. In frequented and populous districts, change of horses may commonly be procured at intervals of from eight to twelve miles, and in the most remote and thinly inhabited at inns not more than from fifteen to twenty miles apart. The trade is wholly in the hands of private speculators. The rate of travelling with post-horses varies according to the weight of the carriage and the number of horses employed; from eight to nine miles an hour may be stated as the average rate of a pair of horses under ordinary circumstances. The number of horses hired depends solely on the will and discretion of the party hiring, which are controlled by no legal regulation whatsoever. The payment is estimated per mile for each pair of horses, without reference to the number of persons conveyed, and a second pair of horses is charged at the same rate as the first; the payment to the postmaster does not include the driver, who expects a gratuity of about three-pence a mile. Four horses is the greatest number ever required for one carriage. Sixteen or eighteen pence per mile is the usual price for each pair of horses, and when the payment of postboys and turnpikes is added, a journey will be found to cost about twenty-two pence a mile. If a post-chaise or fly be required as well as post-horses, no additional charge is made on account of the carriage. Post-chaises are now almost things of the past; but flys with a single horse are to be had at most towns, and all large inns, at about 1*s.* a mile. The price of posting is nearly uniform throughout England, but there is considerable variation in the degree of goodness of the horses and chaises provided. On much-frequented roads, where there is generally competition in the posting trade, the accommodation is very superior to what is found at little-frequented inns, where an inferior description of post-horse is kept, which is often insufficiently fed because it is not frequently employed. A postmaster pays yearly for one horse and carriage, 7*l.* 10*s.*; for two, 12*l.* 10*s.*; increasing with the number, for a licence to let post-horses.

POSTULATE (*postulatum*, *αἴτημα*), a thing required to be granted, or the use of which in reasoning is *demanded*.

The distinction between a postulate and an axiom lies in this—that the latter is admitted to be self-evident; while the former may be agreed upon between two reasoners and admitted by both, but not as a proposition which it would be impossible to deny. The distinction above made is really necessary; for example, writers on the evidences of Christianity assume the existence and attributes of the Creator as postulates: they take them for granted. A person who is in the habit of not distinguishing the senses to which the words postulate and axiom have been affixed above, might say they assume the existence and attributes above mentioned as axioms, by which another person might understand things necessarily indisputable; while the writers themselves only mean by the assumption, that what they take for granted has been previously proved by writers on natural theology; or, at any rate, that until they are admitted, the question of the evidences cannot be entered upon. The confusion which prevails as to the use of the word axiom would be lessened by the introduction and proper use of the word postulate, which is our reason for adding these few words to what has been said under AXIOM.

POTASH. [POTASSIUM.]

POTASH ALUM. [ALUM.]

POTASSA. [POTASSIUM.]

POTASSIUM (K). This metal was discovered in 1807 by Sir Humphry Davy. Most of its compounds had been known for years prior to that date, and that the basis of them was a metal, that they were in fact compounds of a metallic oxide, had long been suspected. In that year, however, Davy succeeded in isolating the metal by submitting fused hydrate of potash to the action of a powerful voltaic battery. Potassium has since been obtained by more facile methods, and the following is the one now generally adopted.

Crude bitartrate of potash (argol) is heated in a covered iron pot till gases cease to be evolved. The product—a mixture of carbonate of potash and finely divided carbon—is triturated in a mortar, while still hot, with some coarsely powdered charcoal, and the porous mass promptly transferred to an iron mercury bottle, or other wrought-iron retort. A neck is formed to the bottle or retort by simply screwing into the mouth a piece of iron tube about six inches long, and the whole is then so imbedded in a furnace as that the open end shall project about a quarter of an inch through an opening in that side of the furnace that is purposely formed of plate iron. The fire is now lighted and fed with a mixture of coke and charcoal; an intense white heat is thus produced, and vapours of potassium soon appear at the mouth of the apparatus, and burn with a brilliant purple flame. A receiver is now fitted on, the construction of which needs some care; it may be so formed that the potassium shall drop into naphtha the moment it solidifies; or it may merely be an iron box five inches wide, twelve long, and a quarter of an inch deep, formed by clamping together two very shallow wrought-iron dishes made of plate-iron one-sixth of an inch in thickness. In either case an opening must be made exactly opposite the neck of the bottle, in order to allow of the latter being cleared by a stout steel wire in the event of its becoming stopped up by condensed potassium, &c.; such an opening also allows of the escape of the carbonic oxide gas that is abundantly evolved during the process. The receiver must be kept cool by ice, or other convenient means, and, in the case of the flat box, must, at the close of the operation, be plunged under the surface of rectified Persian naphtha as otherwise the potassium would quickly become oxidised. The metal thus obtained is not pure, and must be redistilled in a similarly arranged apparatus.

The manufacture of potassium is a somewhat dangerous operation, owing to the frequent formation of explosive compounds. The apparatus in which it has been performed should be immersed in water as soon as cold, for a black detonating compound soon forms by exposure of the residual potassium to the air, and explodes by the slightest friction.

The decomposition that takes place during the manufacture of potassium is primarily a simple case of deoxidation, as expressed in the following equation:—

$$\underbrace{KO, CO_2}_{\text{Carbonate of potash.}} + \underbrace{C_2}_{\text{Carbon.}} = \underbrace{3CO}_{\text{Carbonic acid.}} + \underbrace{K}_{\text{Potassium.}}$$

Unfortunately, however, the liberated potassium has a great tendency to unite with carbonic oxide, and form a very explosive compound of a grayish colour; it is termed *croconaceous* matter, and when dissolved in water yields croconate and *rhodizonate* of potash.

Potassium has so intense an affinity for other elements that it does not occur in nature in the free state. In combination, however, it is frequently met with. Nearly all land plants contain it, derived mainly from disintegration of feldspar—their ashes consequently yield much carbonate of potash; sea-water also contains a small quantity of potash salts, and nitrate of potash occurs native in large quantities as an efflorescence from the soil in warm climates. [POTASSIUM, in NAT. HIST. DIV.]

Potassium is a bluish-white metal of sp. g. 0·865. At 32° Fahr. it is brittle, and has a crystalline fracture; at ordinary temperatures it is quite soft, and at 130° Fahr. it is liquid. A freshly cut surface possesses high metallic lustre, but it almost instantly becomes covered with a coating of white rust. It may be preserved in the bright state by melting it in one end of a glass tube, from which the air has been expelled by a current of hydrogen, or coal gas, and then allowing it to flow down to the other end of the tube, passing in its course through a small piece of wire gauze; the dross is thus filtered away and the metal obtained in a brilliant lustrous condition. On fusing off, by the aid of a blow-pipe, that part of the tube containing the gauze, &c., then melting the potassium and allowing it to cool very slowly, and when partly solidified rapidly pouring off the liquid portion, the solid potassium is obtained crystallised in quadratic octohedra.

Potassium has a great affinity for oxygen. It will take that element out of almost any combination. Thrown on to the surface of water it rapidly becomes converted into oxide of potassium, and generates sufficient heat to ignite the hydrogen that is set free, the latter carrying off a little vapour of potassium and burning with a beautiful violet flame. At an elevated temperature potassium decomposes carbonic oxide, carbonic acid, or any gas that contains oxygen. In chemical research potassium is frequently used for removing the last traces of oxygen from a hydrocarbon liquid, by rectifying the latter over a small quantity of the metal. From what has been said it is evident that potassium must always be kept in purified rock oil, or naphtha, or some liquid that contains no oxygen.

The equivalent of potassium is 38·96.

Potassium and *oxygen* form three compounds:—

1. Suboxide of potassium . . . . . . K_2O?
2. Protoxide of potassium . . . . . . KO
3. Teroxide of potassium . . . . . . KO_3

1. *Suboxide of potassium.*—This is formed when potassium is exposed in a close vessel to a very small quantity of air. It is very unstable, and is probably only a mixture of metal and protoxide.

2. *Protoxide of potassium* (KO). *Potash; potassa.*—This *anhydrous* oxide is formed when the metal is exposed to perfectly dry air; or when equivalent weights of water and potassium are brought together in a vessel from which air is excluded. It is very deliquescent, and when moistened with water becomes incandescent.

Hydrated oxide of potassium (KO,HO). *Potash; caustic potash.*—This is best prepared by dissolving carbonate of potash in ten times its weight of water and then gradually adding half its weight of quick-lime, previously slaked and made into a cream with water; carbonate of lime deposits, and caustic potash remains in solution. The resulting liquid frequently contains alumina. Solid hydrate of potash is obtained on evaporating the liquor, just mentioned, until the residue remains in a state of tranquil fusion; it was formerly called *lapis infernalis*. It crystallises in acute rhombohedra. The following is Dalton's table of the strength and boiling point of caustic potash solutions of different specific gravities:—

	Anhydrous Potash (KO).	
Specific gravity.	Per cent.	Boiling Point.
1·68	51·2	329° Fahr.
1·60	46·7	290° ,,
1·52	42·9	276° ,,
1·47	39·6	265° ,,
1·44	36·8	255° ,,
1·42	34·4	246° ,,
1·39	32·4	240° ,,
1·36	29·4	234° ,,
1·33	26·3	229° ,,
1·28	23·4	224° ,,
1·23	19·5	220° ,,
1·19	16·2	218° ,,
1·15	13·0	215° ,,
1·11	9·5	214° ,,
1·06	4·7	213° ,,

The *liquor potassæ* of the London Pharmacopœia has a density of 1·063.

3. *Teroxide of potassium* (KO_3) is formed when the metal is burned in excess of oxygen gas, or when caustic potash is fused in contact with air. It is a yellowish brown substance, having a crystalline texture, and readily parts with its oxygen to combustibles, and even on dissolving in water.

Potassium and *phosphorus* may be fused together under rock oil, with production of a chocolate-brown phosphide of potassium. Water decomposes it into hypophosphite of potash and into gaseous and solid phosphuretted hydrogen.

Potassium and *sulphur* form five different compounds, namely:—

1. Protosulphide of potassium . . . . . KS
2. Bisulphide of potassium . . . . . . KS_2
3. Tersulphide of potassium . . . . . . KS_3
4. Tetrasulphide of potassium . . . . . KS_4
5. Pentasulphide of potassium . . . . . KS_5

1. The first is formed on heating sulphate of potash in a current of hydrogen. Its colour is yellowish-brown, it is very deliquescent, and cauterises the skin. 2. The second is formed on passing excess of sulphuretted hydrogen through an alcoholic solution of potash, evaporating in the air till it becomes turbid, and then exposing it in vacuo. It is fusible, and of an orange colour. 3. Tersulphide of potassium is obtained on passing bisulphide of carbon vapour over ignited carbonate of potash. 4. The tetrasulphide results when bisulphide of carbon vapour is passed over ignited sulphate of potash. 5. Pentasulphide of potassium is formed when a solution of any of the preceding sulphides is boiled with excess of sulphur; or, mixed with other potash salts, when caustic potash is boiled with excess of sulphur; or when carbonate of potash is fused with excess of sulphur. *Liver of sulphur* is an old preparation, made by fusing together 69 parts of carbonate of potash with 40 of sulphur; it is mainly a mixture of sulphate of potash and tersulphide of potassium. With the exception of the first, all the above sulphides of potassium yield sulphuretted hydrogen and free sulphur on being decomposed by a dilute acid, thus:—

$$KS_n + HCl = KCl + HS + S_{n-1}.$$

Potassium and *selenium* form compounds apparently resembling the sulphides.

Potassium and *iodine* form only one compound, namely,—

Iodide of potassium (KI). *Hydriodate of potash.* This salt is much used in medicine. It may be made by dissolving iodine in caustic potash, evaporating to dryness, and gently igniting the residue to drive off the oxygen from the iodate of potash that is produced at the same time:—

$$\underbrace{6KO}_{\text{Potash.}} + \underbrace{I_6}_{\text{Iodine.}} = \underbrace{5KI}_{\substack{\text{Iodide of}\\\text{potassium.}}} + \underbrace{KO, IO_5}_{\substack{\text{Iodate of}\\\text{potash.}}}$$

Or it may be formed by fusing iodine with excess of iron, decomposing the iodide of iron solution by carbonate of potash, filtering, and evaporating to the crystallising point.

$$\underbrace{FeI}_{\substack{\text{Iodide of}\\\text{iron.}}} + \underbrace{KO, CO_2}_{\substack{\text{Carbonate of}\\\text{potash.}}} = \underbrace{FeO, CO_2}_{\substack{\text{Carbonate of}\\\text{iron.}}} + \underbrace{KI}_{\substack{\text{Iodide of}\\\text{potassium.}}}$$

Iodide of potassium crystallises in white cubes, having a cooling somewhat bitter taste. It is very soluble in water, and, if pure, completely dissolves in six times its weight of alcohol. It readily dissolves iodine, forming a deep brown solution.

Potassium and *bromine* form *bromide of potassium* (KBr). It may be prepared by the same methods as the iodide, substituting bromine for iodine. Its appearance is also similar.

Potassium and *chlorine* form—

Chloride of potassium (KCl). Potassium burns in chlorine with even greater brilliancy than in oxygen; the product is chloride of potassium. This salt may also be formed by dissolving carbonate of potash in hydrochloric acid, and evaporating to the crystallising point. Chloride of potassium is a bye-product in many pharmaceutical and chemical operations, and, from the facility with which it may be decomposed, is useful as a source of other potash salts.

Potassium decomposes *hydrofluoric acid*, and forms *fluoride of potassium* (KF). It crystallises in cubes.

Silico-fluoride of potassium (KF, SiF_2) falls as a transparent gelatinous precipitate on adding hydrofluosilicic acid to a salt of potash. Its formation is sometimes used as a test for potash.

Carbonate of potash (KO, CO_2). This salt is imported in large quantities from Russia and America. It is procured from plants, which for this purpose are burned in dry pits three or four feet deep, the ashes dissolved in water, evaporated until the phosphates, sulphates, chlorides, &c., crystallise out, and the mother liquor then boiled to dryness. Such is the *crude potash* or *pearlash* of commerce; it varies very much in quality, but its value is always determined by the process of ALKALIMETRY. After recrystallisation till pure, it is sent into the market as *salts of tartar*, or *purified pearlashes*.

Chemically pure carbonate of potash may be obtained by heating the bicarbonate to a little below redness, or by deflagrating a mixture of equal parts of nitrate and bitartrate of potash: either product is digested in water, filtered, and evaporated to the crystallising point.

Carbonate of potash crystallises in deliquescent, oblique, rhombic octohedra, containing two equivalents of water of crystallisation (KO

$CO_2 + 2Aq.$). It has an acrid, soapy taste, is strongly alkaline to test-paper, is soluble in rather more than its own weight of cold water, and in rather less than half its weight of hot water. The strength of its solution may be ascertained by its specific gravity according to Tunnerman's table :—

Specific gravity.	Per cent.	Specific gravity.	Per cent.
1·4812	40·504	1·2282	19·580
1·4750	40·139	1·2150	18·601
1·4626	39·160	1·2020	17·622
1·4504	38·181	1·1892	16·643
1·4384	37·202	1·1766	15·664
1·4265	36·223	1·1642	14·685
1·4147	35·244	1·1520	13·706
1·4030	34·265	1·1400	12·727
1·3918	33·286	1·1282	11·748
1·3803	32·307	1·1166	10·769
1·3692	31·328	1·1052	9·790
1·3585	30·349	1·0940	8·811
1·3480	29·360	1·0829	7·832
1·3378	28·391	1·0719	6·853
1·3277	27·412	1·0611	5·874
1·3177	26·432	1·0505	4·895
1·3078	25·454	1·0401	3·916
1·2980	24·475	1·0299	2·934
1·2836	23·496	1·0108	1·958
1·2694	22·517	1·0098	0·979
1·2554	21·538	1·0048	0·489
1·2417	20·539		

Carbonate of potash is insoluble in alcohol. It fuses at a red heat, and slowly volatilises at a still higher temperature.

Carbonate of potash is largely used in the manufacture of soap and of glass, and is a convenient salt for the preparation of other potash compounds.

Bicarbonate of potash ($KO, HO, 2CO_2$) is formed when moist carbonate of potash is exposed to the influence of a current of carbonic acid. It forms permanent right-rhombic prisms. Its solution is neutral to test-paper, and by long exposure to air or a boiling temperature is gradually reduced to the state of solution of *sesquicarbonate*.

Borates of potash. There are several of these. The biborate crystallises in six-sided prisms, and resembles borax. [Boracic Acid.]

Phosphates of potash. The different varieties of phosphoric acid [Phosphorus] form salts with potash, but the resulting compounds have no particular interest.

Sulphite of potash (KO, SO_2) and *bisulphite of potash* ($KO, HO, 2SO_2$) may readily be obtained, but the corresponding soda-salts [Sodium] are nearly always used in their place.

Sulphate of potash (KO, SO_3). *Sal polychrest.* Bisulphate of potash is neutralised with carbonate, and evaporated; the resulting sulphate of potash much resembles quartz in appearance. It requires 16 parts of cold water for solution, but is much more soluble in hot water. It is very hard, and forms double salts with many other protosulphates, and with those sesquisulphates that are isomorphous with sesquisulphate of alumina. [Alums.]

Bisulphate of potash ($KO, HO, 2SO_3$). *Sal enixum.* A bye-product in the distillation of hydrochloric or nitric acids. It is much more soluble in water than the neutral sulphate, and crystallises in prisms or plates.

A *sesquisulphate of potash* ($2(KO, SO_3) + HO, SO_3$) also exists.

Hypochlorite of potash, chloride of potash, or *chlorinated solution of potash* ($KO, ClO + K, Cl$ for $2(KO, Cl) = KCl + KO, ClO$). Obtained on passing chlorine into solution of potash. It is a disinfectant; but the corresponding soda-salt is more generally used.

Chlorate of potash (KO, ClO_5), *oxymuriate of potash,* is formed on passing chlorine gas into a mixture of 69 parts of carbonate of potash with the slaked lime that is obtained from 168 parts of quick lime. The resulting mass is lixiviated with water, and evaporated till the chlorate crystallises out. The decomposition is thus expressed :—

$$\underbrace{KO, CO_2}_{\substack{\text{Carbonate}\\ \text{of potash.}}} + \underbrace{5(CaO, HO)}_{\substack{\text{Hydrate}\\ \text{of lime.}}} + \underbrace{Cl_6}_{\text{Chlorine.}} = \underbrace{KO, ClO_5}_{\substack{\text{Chlorate}\\ \text{of potash.}}} + \underbrace{5CaCl}_{\substack{\text{Chloride}\\ \text{of calcium.}}} + \underbrace{5HO}_{\text{Water.}} + \underbrace{CO_2}_{\substack{\text{Carbonic}\\ \text{acid.}}}$$

Chlorate of potash is soluble in 16 parts of cold water, but in less than twice its weight of boiling water. It has a cooling saline taste. When heated, it parts with the whole of its oxygen. [Oxygen.] It is a powerful oxidising agent, and is used in certain operations connected with calico-printing and in the manufacture of lucifer matches.

Perchlorate of potash (KO, ClO_7) is obtained, as already described [Chlorine, *Perchloric Acid*], in small crystals derived from the octohedron.

Nitrite of potash (KO, NO_3). [Nitrogen.]

Nitrate of potash (KO, NO_5). *Nitre. Saltpetre.* This important salt occurs native, as already described. Nearly all the nitre used in this country comes from the East Indies. The soil in the neighbourhood of Tirhût, one of the most productive districts, contains on the average about 7 parts of nitrate of potash and rather more nitrate of lime in 1000 parts. The solution of these salts, brought to the surface of the ground by capillary action, is rapidly dried by the wind and sun, and the salts remain behind as a frost-like efflorescence. The natives scrape up the deposit from time to time, mix it with carbonate of potash in the shape of solution of wood-ashes, and evaporate the solution to dryness. The use of the carbonate of potash is to decompose the nitrate of lime, carbonate of lime being precipitated and nitrate of potash remaining in solution along with that originally present. After a second solution and crystallisation, it is sent into commerce, though still impure.

The analysis of crude nitrate of potash, or the estimation of the amount of real salt contained in it, is technically termed the *refraction of nitre.* Many processes have been devised for the accomplishment of this object, but each requires modification according to the variety and apparent amount of the impurities. They are all more or less based upon the ordinary method adopted in general chemical analysis. Frequently, the only required information is the amount of nitric acid contained in a sample. To this end, about 10 grains are weighed into a porcelain crucible, then fused to drive off water, cooled, a weighed quantity of sulphate of lead added, the whole re-ignited till no more fumes are evolved, and again weighed. The loss sustained during the second heating is due to nitric acid; for nitrate of potash—and indeed other nitrates—are decomposed when heated with sulphate of lead, sulphate of potash and oxide of lead remaining, while the whole of the nitric acid is given off as peroxide of nitrogen and oxygen.

In many parts of the continent of Europe, the nitrogen in every description of refuse animal and vegetable matter is converted into the form of nitric acid, and thence into nitrate of potash, by exposing heaps of offal, mixed with old mortar, slaked lime, chalk, and earth, to the free action of the air, but protected from the rain; the whole being occasionally watered with stale urine, stable runnings, &c. Great care and skill is often bestowed upon these *saltpetre beds* or *nitre plantations*, as they are called, and after two or three years' exposure, the end first formed is lixiviated with water and treated as before described for obtaining nitrate of potash. In the above putrefactive process of *nitrification*, the nitrogen, as usual, first takes the form of ammonia, and this in the presence of the lime is gradually oxidised by the air to nitric acid: a temperature below 60° Fahr. prevents this action.

The chief use of nitre is in the manufacture of Gunpowder. It is to some extent employed in medicine, and when fused and cast into cakes or bullets is frequently called *Sal Prunella.*

Chromates of potash. The *neutral* salt (KO, CrO_3) is formed on neutralising the bichromate with carbonate of potash. By evaporating the solution it may be obtained in transparent yellow prisms. The *bichromate* ($KO, 2CrO_3$) is obtained directly from ground chrome iron ore, by fusion with carbonate of potash and nitre. The resulting mass is digested in water, the liquid saturated with nitric acid and evaporated to the crystallising point. Bichromate of potash crystallises in large ruby red four-sided tables. Its chief value depends upon the chromic acid it contains. See Chromium, and Lead, *Chromates of.* A *terchromate of potash* ($KO, 3CrO_3$) also exists.

Acetates of potash. [Acetate.]

Tartrates of potash. [Tartaric Acid.]

Oxalates of potash. [Oxalic Acid.]

Cyanide of potassium (KCy). Formed by fusing together eight parts of anhydrous ferrocyanide of potassium, three of dried carbonate of potash, and one and a half of charcoal. The resulting mass is digested in water, filtered or decanted, and evaporated to dryness. From solution in alcohol it crystallises in colourless cubes. It is used for forming and dissolving the cyanides of gold and silver in electro-gilding and plating, and in photography. It is a powerful reducing agent, and is exceedingly poisonous. It forms double salts with other cyanides. [Cyanogen.]

Ferrocyanide of potassium ($K_2Fcy + 2Aq.$) *Yellow prussiate of potash.* This salt is prepared by heating together, in a covered iron pot, a mixture of about five parts of horn parings, hide clippings, horse's hoofs or other similar refuse animal matter, with about two parts of pearlash, and a quantity of scrap iron. At the high temperature employed the nitrogen and carbon combine to form cyanogen, and this, with the iron and potassium of the pearlash, forms ferrocyanide of potassium. On digesting the cooled mass in water and evaporating the solution, the salt crystallises out in large yellow crystals derived from the octohedron.

Ferridcyanide of potassium (K_3Fdcy). *Red prussiate of potash.* This salt is formed on passing chlorine through a dilute solution of the ferrocyanide, till the latter ceases to give a blue precipitate with a persalt of iron. On evaporation and recrystallisation magnificent ruby red prisms are obtained. For the relative composition, probable constitution, and uses of ferrocyanide and ferridcyanide of potassium, see Cyanogen; Ferridcyanic Acid; Ferrocyanic Acid; Metals, *Iron, ferrocyanogen* and *ferridcyanogen*; Blue, *prussian blue.*

Sulphocyanide of potassium. See Cyanogen.

Potassium-amide $\left(\left.\begin{matrix}K\\H\\H\end{matrix}\right\}N\right)$ is a primary inorganic monamide, formed on gently heating potassium in a current of dry ammoniacal gas; hydrogen is at the same time evolved. It is a fusible, semi-crystalline, olive-green compound. Heated to redness it is decomposed, a greenish-black infusible body remaining, which is the corresponding tertiary monamide, or *nitride of potassium* $\left(\left.\begin{matrix}K\\K\\K\end{matrix}\right\}N\right)$.

Detection of potassium. The salts of potassium are characterised, first, by communicating a purple colour to the blowpipe flame; second, by affording a crystalline precipitate on being mixed with excess of a saturated solution of bitartrate of soda—this test may not succeed if the potassium be present only in small quantity; third, by giving a yellow granular precipitate on the addition of bichloride of platinum.

Estimation of potassium. This is usually effected in the state of the double chloride of potassium and platinum just mentioned $(KCl, PtCl_2)$. The substance—from which all other metals have been separated by the ordinary system of analysis—is acidulated with hydrochloric acid, the bichloride of platinum added, and the whole evaporated to dryness. The residue is then washed with a mixture of alcohol and ether, and weighed on a tared filter; 100 parts are equivalent to 15·98 of potassium, or 19·26 of potash (KO).

POTASSIUM, OXIDE OF, POTASSA or POTASH, *Medical Properties of.* The preparations of potash which are used in medicine are very numerous; but they may be reduced and spoken of under a very few heads:—First, those which are employed from their causticity to produce counter-irritation, or to open abscesses: these are hydrate of potash (potassa fusa) and potash with lime (potassa cum calce), which have been already treated of. [Escharotics.] Second, those which are employed to counteract acidity, namely, liquor potassæ, carbonate and bicarbonate of potash, the alkalinity of which last two is diminished in proportion to the increase of the carbonic acid combined with the alkali. Thirdly, those which possess a purgative property, such as the sulphate and bisulphate of potash, the tartrate and bitartrate. Fourthly, those possessed of a diuretic property, such as the acetate, and, when in small doses, the tartrate, bitartrate, the nitrate and chlorate of potash. Besides these, there are the sulphide of potassium, the bromide of potassium, and iodide of potassium, which possess special and characteristic qualities, which prevent their being classed with any of the preceding. Chlorate of potash is of great utility in the treatment of diphtheria.

The various uses of which these numerous preparations are susceptible can only be explained in medical treatises: all that is proper here is to caution individuals against the employment of those which counteract acidity. These are extensively had recourse to, either in a simple state or as ingredients in effervescing mixtures, for the cooling effect they produce, or designedly to remove superfluous acid in the stomach. Where much debility exists, and more particularly if the phosphatic diathesis, or disposition to the deposit of the phosphates from the urine, be present, a single dose of such articles may do much injury, and their frequent or prolonged use creates a worse condition than that which they were intended to remedy. But this does not preclude the employment of a solution of carbonate of potash to induce a coating of phosphates over the sharp angles of the mulberry or oxalate of lime calculus. [Oxalic Acid.] An intelligent medical attendant can alone decide on their propriety. "If I were required," says Dr. Prout, "to name the medicine calculated to do the most mischief, I should name the common saline draught formed of potash or soda and some vegetable acid." ('Treatise on Diseases of the Urinary Organs,' 2nd edition, p. 145.) [Carbonic Acid.] This remark equally applies to many of the popular summer beverages, such as imperial; and many effervescing drinks prepared with lemon and kali.

The property assigned to bromide of potassium, of removing enlargements of the spleen, is by no means clearly proved. The powers of iodide of potassium have been noticed under Iodine, and those of the sulphide of potassium are treated of under Sulphur. In case of poisoning by liquor potassæ or the carbonates, vegetable acids or oils should be instantly administered.

POTASSIUMAMIDE. [Potassium.]

POTASSIUMETHYL. [Organo-metallic Bodies.]

POTATO (*Solanum tuberosum*, Lin.). The circumstances which led to the introduction of this valuable vegetable into the system of British husbandry may be thus succinctly stated:—

Queen Elizabeth, in 1584, granted a patent "for discovering and planting new countries not possessed by Christians;" and under this sanction some ships, principally equipped by Sir Walter Raleigh, sailed with him to America. Thomas Harriott (afterwards known as a mathematician), who accompanied the adventurous squadron, transmitted to England the description of a plant called *Openawk* by the natives of that part of North America which the courtier-like gallantry of Raleigh had named Virginia.

Harriott described the *Openawk* as having the roots round, and "hanging together as if fixed on ropes, and good for food, either boiled or roasted." Gerarde, in his 'Herbal,' a few years subsequently, distinguished the plant by a plate; and not only confirmed the assertion that it was an indigenous production of Virginia, whence he himself had obtained it, but supplied some curious details of its qualities, and of the various modes in which it may be dressed for the table. He especially recommended it as the basis of "delicate conserves and restorative sweetmeats," with the assurance that its flatulent effects may be infallibly corrected by having the roots "eaten sopped in wine;" adding, "to give them the greater grace in eating, they should be boiled with prunes."

The honour of first cultivating the potato in Ireland, where it has so long constituted the principal food of the peasantry, has been attributed to the grandfather of Sir Robert Southwell, president of the Royal Society of London, towards the close of the 17th century. Sir Robert's statement was to the effect that his ancestor had obtained some roots from Sir Walter Raleigh.

But the potato had been known in Spain and Portugal at an earlier period, and it is from the latter country that we most directly derive the name by which we know it: this is easily shown. Although the natives of North America called our plant openawk, those of the south, more particularly the inhabitants of the mountains of Quito, called it papas, which the Spaniards corrupted into battata: this again their neighbours in Portugal softened into ba-ta-ta (da terra), to which po-ta-to is a very close approximation.

The potato was cultivated in Ireland long before its introduction into Lancashire, which was owing to a shipwreck, it is said, at North Meols, at the mouth of the Ribble, where the mode of propagation still maintains pre-eminence, and whence the culture of this important plant has gradually spread through every portion of Great Britain.

It was not, however, until after a considerable time that it became palatable, productive, and farinaceous, or admitted into the course of field husbandry. It was limited to the garden for at least a century and a half after it was first planted at Youghal, and it was not until 1732 cultivated as a field crop in Scotland. It appears (from the 'General Report of Scotland') that in the year 1725-6 the *few* potato plants then existing in gardens about Edinburgh were left in the same spot of ground from year to year, as recommended by Evelyn: a few tubers were perhaps removed for use in the autumn, and the parent plants were well covered with litter, to save them from the winter's frost.

Though the plant may be propagated both by its seed and tubers, practical management has confined the cultivation to the latter mode, except for the purpose of raising new varieties or renewing old ones. Those who are curious about varieties (which are now innumerable), can almost indefinitely pursue their object; for the seed of a species, the red apple for example, will sport, and this too without hybridising (that is, without the admixture of its seed with that of any other species, the produce of which would be hybrids), into numberless varieties of form and colour—round, flat, oblong, red, pink, black, white, mixed, and purple, of every shade and colour. These, whether hybrids or not, are reproduced through successive seasons by the tubers alone, if they possess those qualities which render them desirable for continued cultivation, on account of peculiar adaptation to early or late seasons, size, predominance of farina, &c.*

This mode of propagation by tubers either improves those qualities, or gradually developes objectionable properties. Some varieties are therefore permanently established, while the culture of others is either abandoned, or, if continued, it is known that those varieties revert in the course of a few generations to the nature of their parent kind, and therefore cease to constitute a variety.

In the vegetable kingdom, hybrid plants have not the power of propagation by seed; but they can be rendered reproductive by budding and grafting, or by means of cuttings, slips, and tubers, and an original stock comparatively worthless may be highly improved by such modes of multiplication. But when a farmer possesses two or three kinds of decided excellence, he will act wisely by not encumbering his stores with too many varieties, which always occasion trouble and confusion in the field management.

In order to obtain seed, properly so called, the potato-apple, when perfectly ripe, should be dried, and then disengaged from its seed by rubbing with the hand. The seed should be preserved in a dry place, in paper or cloth bags, until the beginning of March or middle of April, when it may be sown in wooden boxes or earthen pans, with a covering of less than half an inch of well pulverised earth. The vessels ought then to be placed in hotbeds of mild heat, such as is suited to the raising of half-hardy annuals. The plants, when an inch high, should be pricked out into other vessels, and placed in a temperature somewhat lower than before, to inure them to the external air, to which they should be exposed after frosts have ceased. These plants should be put out in drills sixteen inches apart, and with the interval of six inches between the plants in the rows. They will produce tubers in the first year, and these may be planted in the following season in the ordinary way.

For very early crops, such as those which the ash-leaved and walnut-leaved kinds in particular yield, the most successful treatment was that practised by the late Mr. Knight, president of the London Horticultural Society, from the course of whose practice we give the following details of instruction:—Drills may be formed in a warm and sheltered situation (and in the direction of north and south) during any of the winter months, two feet apart, and seven or eight inches deep. Stable dung, half decomposed, should be laid in the drills and combined with the earth four inches downwards, and covered with some of the mould, which had been thrown out in forming the drills, by the rake, to within four inches of the surface. The sets uncut are then to be placed, with the crown eye uppermost, in the centre of the furrow, four inches from each other, and to be covered with only an inch of mould at first, and afterwards with an occasional quantity of sifted ashes, until the plants are so vigorous and advanced as to require the usual earthing, of which, however, very little is necessary. Mr. Knight used leaves as a lining at the sides of the drills in the early periods, to preserve as much warmth as possible, and better to guard against the effects of frost.

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* M. Sargeret, a distinguished and accurate French experimentalist, referred to in the 'Dictionnaire d'Agriculture,' found that out of 300 varieties he had only one exactly like the original from which they were raised; and out of this great number he only found three worth perpetuating.

This management alone will be found successful, except perhaps in very tenacious clay soil, in which the rains of winter may lodge so near the fibres of the plants as to destroy them altogether; but destruction from this cause may easily be avoided by increasing the original depth of the furrows and loosening the bed of clay below with the spade to such a depth as will allow the water to descend from the surface, with a drain to carry it off altogether; or by laying below some absorbent matter, such as ashes, chalk, or calcareous gravel.

The germination of the sets may be accelerated by a little management previously to their being planted, by laying them on a floor, sprinkling them with water until they bud, and then covering them with finely-sifted mould. If this be done in December or early in January, the sets, with strong shoots, may be taken up in February (with as much earth as possible adhering to them), and carefully placed in the drills prepared as directed, and covered with well-rotted leaves or earth in the same way.

To market-gardeners it is a great object to raise the earliest potatoes, considering the high price which they obtain for them, though in their waxy state they are neither wholesome nor palatable. Next in early maturity to the ash-leaved and walnut-leaved are the early Manly and early Champion and Fox's seedling.

The best soil for potatoes generally is that which is altogether fresh from the state of lea, or which has not long been broken up: land which has been in grass for only two or three years is easily prepared for the principal crop. It should be as deeply ploughed as possible before winter, and early in March harrowed, and thoroughly cross-ploughed. After lying in this state for two or three weeks, it should again be well harrowed and very deeply ploughed twice, without bringing up any bad substratum, and it will then be fit for the reception of the crop.

The most approved modes of setting are as follows:—Drills should be formed in the well-pulverised field with double boutings of the plough, in order to have the shoulders uniform, which is essential to the correctness of succeeding operations. The dung is then to be carted out, and divided by the carter with a drag-fork as his horse and cart move forwards (the horse walking in the centre of three drills while the wheels move in the other two), in such quantities as can be most conveniently shaken out into the drills by the labourers employed to spread it. In dry weather the carting does no injury, and this method is universal in Scotland. The other principal mode, more generally pursued in Ireland by some of the best cultivators of the potato, is to cart out the manure before the drills are formed, in rows seven or eight yards apart, and to supply the drills from the heaps as the plough advances in its work, reserving just as much as is supposed sufficient for the concluding drills, which are to be made in the sections of the field previously occupied by the rows of manure. By the latter treatment the manure may be laid over the sets—which cannot be done in the former case—and this will preserve them from being displaced or crushed by the feet of the horses during the process of covering the seed. But against this advantage—which is not inconsiderable—there is the inconvenience of calculating with precision and laying aside as the plough advances to draw the last drills—where the rows had stood—the precise complement of manure, and the difficulty to the ploughman of preserving the exact breadth in those drills.

Some avoid any perplexities in those respects by ploughing in the manure thoroughly before drilling, and either dropping the set in every third furrow, or rolling the whole manured and ploughed surface, and then making drills. Our own experience is greatly in favour of this latter mode, when the fertilising matter is abundant and of the short description which freely combines with the soil, and does not obstruct the plough in the subsequent drilling. The lazy-bed method is so generally condemned, that any explanation of it here would be superfluous, yet in undrained bog-land, or under any circumstances in which a redundancy of wetness is probable in the autumn, as on low marshy lands, or stiff clay soils which have no sufficient inclination to carry off the water, and are likely to be saturated with moisture in winter from want of drainage, the lazy-bed system is by far the safest. The deep wide furrows at each side carry off the water, or at least remove it from the potato. Thousands of tons of potatoes in the year 1839 were utterly lost in Ireland, being drilled in flat and tenacious lands, which would have escaped destruction from the continued rains of that season if drained by the furrow of the lazy-bed. Besides, where circumstances preclude the practicability of deep ploughing, the lazy-bed practice repeated for three years will completely spade-trench the entire land, and thus effect an important benefit not otherwise attainable by the humble tiller of the soil who has no teams for ploughing it effectually. Thus local or national modes, though apparently defective to the superficial observer, are sometimes founded upon sound principles, and though we feel disposed to exclude the minute details of what is only defensible under peculiar circumstances from an essay on potato culture under our modern system, we protest against the unqualified condemnation of a method which is still pursued throughout a great part of Ireland.

The sets (uncut, for reasons to be yet assigned) are next to be laid down, either under or over the manure, at the average distance of sixteen inches, by the setters, who move in a retrograde direction, and are provided with aprons to contain the sets. A sufficient number of men are in attendance to divide the manure evenly in the drills; the plough also is in the field in order that there may be the least possible exposure of the manure and sets to the sun or to parching wind, but the plough should cover the sets rather lightly in clay soil.

The roller is next used to lay an even surface to the brairding* plants, and to facilitate the subsequent progress of the paring plough, which is to be set to work when the stems are six or seven inches high, and should move as close to the plants as is practicable without injuring their tender fibres. The weeders should then hoe the plants carefully, and immediately afterwards (for the influence of wind or hot air on the roots is pernicious) the scuffler or drill-harrow is to follow, in order to clean and level the intervals, before the earthing plough, with either double or single mould-board, is introduced to apply fresh earth to the stems.

Such is the method of earthing universally pursued by the farmer in Ireland and Scotland, but in England the hand-hoe is principally used for destroying weeds, loosening the earth, and moulding the plants; for the two first of these operations the bean-hoe (which cuts about six inches deep) is used, and the turnip-hoe for drawing the earth to the stems. One man will hoe out the weeds and loosen the soil of half an acre per day, and the subsequent earthing of the same quantity is also executed by one man. This is far cheaper than horse-work, and it does no injury to any of the stems, and makes no waste land at the headriggs; and where the earth has been perfectly well prepared at the commencement, this manual husbandry is the best.

As to the distance between the drills, due regard must be had to the natural quality of the soil and the quantity and description of manure available, or in other words, to the probable luxuriance of foliage. Mr. Knight, aware of the necessity of allowing room in proportion to the vigour and height of the plants, has laid down an exact rule thus: —"The height of the stems being three feet, the rows ought to be four feet apart:" but for a general average, thirty inches is the best distance. As to excess of foliage, we are certain that it is not desirable, for the produce of tubers is not always in proportion to the degree of foliage; under high and rank stems there is often a very scanty crop, and Mr. Knight is justified by experience in his observation that "the largest produce will be obtained from varieties of rather early habits and rather low stature, there being in very tall plants much time lost in conveying the nutriment from the soil to the leaves," and consequently strong and upright stems, which do not fall down and shade the others, are those which are desirable.

Two more earthings are usually given, but it is questionable whether even one be necessary in soil of average depth, unless there be a very wide interval between the drills, and it is certain that much earthing in dry and shallow soil is injurious; for by withdrawing the earth from contiguity to the fibres which ramify and penetrate far in loose soil, and laying it on the head of the drill, and in the high ridgelet form, it is applied where it is useless for the nourishment of the tubers, and in a position that favours the rapid escape of moisture, which in such soil it ought to be an object to retain. In deep land, more particularly if it be of tenacious quality, the furrows at each side of the drill will be in general seasons most serviceable as drains, as well as for furnishing earth to support the stems, while the moisture will be sufficiently retained for the roots.

Experiments† have led to the inference that in soil of a loose porous quality there is probably a greater produce by not affording any (or a very slight) moulding, but by digging instead between the rows; for deep and perfect pulverisation, next to an adequate allowance of rich manure, is the main cause of a large produce. In proportion to the deficiency of manure will be the necessity for opening the soil beneath, to allow the fibres, which may be distinctly traced to a depth incredible to those who have not followed their ramifications, to extract all the nourishment which the subsoil may afford. If there be an abundance of nutriment above, neither the necessity nor perhaps the inclination for penetrating deeply can exist, and in such cases the operation of earthing by the plough, as long as it can be introduced without injury to the stems, may be useful in many ways, but unquestionably by guarding them from the effects of storm in exposed, and from excessive wetness in low situations. Besides, in regulating this point, regard should always be had to the quality of the potato, for the tubers of some varieties have a tendency to push to the surface, while others tend into the earth, and therefore require a different treatment.

But in all cases the earth should be rendered as loose and friable as possible, by spade, hoe,‡ or plough; and where labour is easily commanded, the spade will be found to be the more efficacious implement in the first course of treatment after the plants are well up.

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* A Scotch term signifying "shooting out."

† See Martin Doyle's 'Cyclopædia of Practical Husbandry,' p. 372.

‡ That kind called the bean-hoe, shaped like an adze.

Some plant one or two sets in the centre of every square yard, but in such cases great and continued earthing, until each square presents the form of a pyramid, is contemplated; and, if our preceding remarks be correct, this treatment is only applicable to deep and retentive soils. Great returns have no doubt been thus obtained, but by this mode there is the least possible incorporation of the manure with the soil.

In minute husbandry, such as that exemplified in labourers' allotments, which excludes the plough altogether, the ordinary and best practice is to lay the sets in rows, after a very deep winter digging, marked with a garden-line. The workman digs precisely as in a garden-plot for cabbages: he clears a little drill, lays the sets straight, puts a sufficiency of manure over them, and then covers from the next spit, which he digs with a spade or a three-pronged fork flattened at the ends, levelling and pulverising as he advances to the distance at which he again puts down his line and forms a new drill. Thus the entire piece is thoroughly loosened, the manure perfectly covered, and every facility given for the hand-hoeing in due course.

The next stage of the potato is that in which it blossoms. It has been recommended to pluck off the flowers. Excessive blossoming is no doubt injurious, but experience has generally proved that the extra cost is hardly defrayed by the additional produce obtained. If the flowers are plucked off, they should be nipped in the early bud.

When the crop is fully ripe, which is indicated by the withering of the stalks, and when the land is free from stones, labourers, in the proportion of about twenty to one plough (half of these being usually men, and the remainder women or young persons), should be set to pull up the stalks, and carefully collect the tubers which may be attached to them, before the plough proceeds in its operation. When it is prepared for work, the men, with prongs flattened at the extremity, are placed at such distances from each other as will give them proper time to fork out the potatoes cleanly for the pickers, who are also stationed at exact distances with a basket between every pair, into which they gather the potatoes.

The common swing-plough may be employed in three ways:—First, in taking off a slice from each side of every drill, and leaving it to the workmen to open out the centre with their prongs; or in its third movement it may turn up this centre, under which the main body of the tubers lie, which is more expeditiously and easily done if the earth be in fit condition. Second, a double mould-board plough with a long sack, and divested of its coulter, may be drawn by two strong horses through the centre of the drills, and completely under the level of the tubers, so as to avoid injuring them, by which means the work-people will be kept exceedingly busy; and if the land be in good friable order, this is the most expeditious mode, and, providing there is a perfect harrowing afterwards, the crop will be taken out with sufficient cleanliness. Third, the crop may be taken up by prongs or long narrow spades without the plough. In wet weather this more tedious but far safer method is frequently adopted, and if the drills be short and the headriggs under crop also, it is the most desirable, effectual, and economical mode. In removing the produce in this manner, it is obvious that the number of gatherers should be much less in proportion to the men than under the other circumstances. The headriggs should evidently be the first parts of the field cleared, to make a free space for the ploughs in the boutings, and for the carts.

One horse will answer for three carts if the distance of draught to the pits be short, by changing him alternately from an empty to a full one; but this only applies to the Scotch and Irish system of draught by single carts and horses. The general mode of securing the crops in pits in the field is the safest. In making the pits—improperly so termed, for the base is only sunk a few inches, and the potatoes are raised considerably in the heaps—the only caution to be observed is that furrows should be cut on all sides to prevent water from lodging or penetrating inwards, and that the earth thrown up and over them, to the depth of four or five inches, should be well beaten with spade or shovel to exclude moisture and frost. The potato-stalks, however apparently dry, should never be laid between the potatoes and the earth in these accumulations, for they soon ferment and rot, and injure all the potatoes in contact with them. Straw is at least useless. The length of the pit depends on circumstances, but the breadth should not exceed four feet, as large accumulations are most liable to fermentations.

Of late years the potato has been extremely subject to disease, which first became apparent generally in 1845-6, when the whole crop in Ireland, the mainstay of the people's food, was lost, and a famine ensued. Since that, the same disease has annually reappeared, blackening the leaves before they become naturally ripe, and rotting the tubers either in the ground or in the heap: so that one-tenth to one-half the crop is lost. The only apparent means of remedying this attack, or diminishing its virulence, is by early planting early sorts in early places, so as to obtain a ripe crop before the time (July and August) when the disease generally shows itself. It is also said to be a palliative of this disease, if not a remedy for it, when, by earthing up the nearly ripened crop, the tubers are covered with at least three inches deep of earth, before the period of attack. Besides this disease, there is "the curl," which is an imperfect formation, and was first generally observed in 1761, when it gave rise to various conjectures and unprofitable discussions: the cause is yet unknown. One thing however is clear, that from a crop of which any part is intended for seed, all the plants affected with curl should be carefully separated before the general removal commences. The dry rot, or decay of the set, which during recent years so fearfully prevailed in many parts of the United Kingdom, is also still unexplained as to its real cause, though the press has teemed with essays and very plausible theories respecting it. The set, though apparently sound when planted, has either failed to germinate at all and rotted away, or has feebly and partially thrown out its sickly shoots. The most contradictory causes have been assigned: over-ripening in the preceding year; under-ripening; fermentation in the pits; fermentation of the set in the ground when placed in contact with hot dung (which is utterly absurd, for when in the ground no injurious fermentation can arise); very hot weather, great drought, hot sun, cold parching wind, dry and heating manure, sea-ware, which is always damp; exhaustion of the kind from a long course of culture, contradicted by many instances in which it appears that the produce of the same variety—for instance the apple—has been successfully cultivated during sixty-five years without any failure; or the loss of vitality from prematurely shooting.

If potatoes have fermented in their accumulated state, they would bear obvious evidence of it, and therefore be rejected. Fermentation cannot be the true cause in every or even the majority of cases, nor does the failure probably proceed from insects in the eyes, as has been suggested, for if so, it is difficult to account for the fact that sets from the same heap planted at one part of the day have totally failed, while others put into the ground at another have pushed forth healthy shoots. As to decay in the land from the contiguity of fermenting manure, "How is it to be proved that the gases evolved by fermenting manure can injure the sets? Fermenting manures would rather stimulate by their warmth, and excite their growth by the aliment which their essential qualities, carbon and ammonia, supply to plants. Why do not the gaseous exhalations from rank and fermenting hot-beds destroy the tender plants which are raised in them?" (Doyle's 'Cyclopædia of Practical Husbandry.')

A partial remedy for dry rot is to be found in the planting of entire tubers. When the cut sets have failed, the entire tubers have resisted premature decay; whether it arises from atmospheric influence, or debility of constitution, or from any of the conjectured causes, the entire tubers resist these noxious influences, and germinate healthily and freely. All reports agree on this point: there is no risk in this case, if the tubers be sound when planted; and it may be added, that in all stages of their growth, the uncut tubers maintain a decided superiority, and yield a corresponding produce.

The farina of the potato, properly granulated and dried, is sold in our shops as arrowroot, or mixed with gum as tapioca, to which it bears the closest resemblance, both in appearance and essential properties. For confectionary the flour is so delicately white, and it is so digestible and nutritious, that it ought to be in more general use, among the children of the poor especially, in the winter season, when they so rarely enjoy the luxury of milk; and the cost is not more than a sixth or seventh of the price of tapioca or arrowroot, if it be made at home. Few housewives are ignorant of the method of obtaining it by the use of a common hand-grater and sieve; but for yielding larger supplies some machinery is necessary.

POTIN, a name given by numismatists to an alloy of brass and other metals, from a French word signifying pot-metal. The term is generally applied to a base metal substituted in the ancient currency for silver, consisting of brass, lead, and tin, with an admixture of a fifth part of silver; the presence of tin constitutes potin, as without this metal the alloy is called *billon*. The coins of the Roman emperors minted in Egypt, some of the early coins of Gaul and Britain, and of the later days of the Roman Empire, are in this metal. [NUMISMATICS.]

POTTERY. The word pottery, derived from the French *poterie*, the Latin *poterium*, and the Greek *potērion*, or drinking-vessel, has been applied to all descriptions of dried or baked clay. The worker or manufacturer is styled potter, and the place or establishment where made, pottery; besides which, the term ceramic, from the Greek word signifying earthenware, and fictile from the Latin, has been applied to objects produced in baked or dried clay. The art of working in clay is of such high antiquity that it appears long prior to the historic period of the human race, and was attributed by all nations to gods or mythical personages. In Egypt, the cradle of the earliest arts and sciences, this art is attributed to god Chnum, and its early invention is proved by the bricks of sun-dried clay, of which some of the oldest pyramids were built [PYRAMID]; the vases of red earthenware found in contemporary sepulchres of the 4th or 5th dynasty, and the representation of potters engaged at their occupation on the wall paintings of tombs of the 4th and 12th dynasties. The brick, the oldest of all pottery, called by the Egyptians *teb*, or "box," and at the earliest period made of sun-dried clay mixed with straw, fragments of red pottery, and other materials, was of the shape of those at present, but of larger proportions, about 5 inches thick, 8 inches wide, and 18 inches long, stamped out of a mould, and impressed, from the commencement of the 18th dynasty, with the names of monarchs, constructions, and other inscriptions, made by a wooden block on its upper surface. Such bricks were extensively used for pyramids, walls, tombs, and other constructions. The early invention of the wheel, and the manufacture of vases, bricks, and other objects of red earthenware in Egypt, are proved by the remains and wall paintings. The wheel was a small circular table placed horizontally, which the potter turned with his hands, not feet, at the earlier period, and produced vases of dark-red earthenware, either polished or dull, of various and simple shapes, and sometimes of large dimensions, applicable for all purposes, and often gaily painted all over with a coating of clay or lime to imitate valuable stones, or ornamented with zones or wreaths and other plain ornaments, or inscribed with names and other inscriptions. Besides this process the Egyptians moulded vases of red ware in the shape of men and animals, and modelled coffins and other large objects. Under the Roman empire figures of gods and lamps were moulded in Egypt, and fragments of pottery were used for receipts and inscriptions till the 6th or 7th century, A.D. But the most remarkable Egyptian pottery was the *porcelain*, or rather fayence, the body composed of a white or gray sand, and the surface covered with a siliceous glaze, often $\frac{1}{12}$th of an inch thick, coloured with the oxides of copper, manganese, silver, and tin. The objects of this material were of small size and generally moulded, and consisted of small tiles, and portions used for inlaying vases, beads, bugles, little figures of deities, and sepulchral figures [Mummy], principally in a blue of different shades, but of remarkable beauty. Under the 19th and subsequent dynasties, the blue gave place to a green porcelain of inferior quality. At the earlier period the art of glazing steatite with this glaze was introduced. The Egyptians appear to have invented this porcelain and retained the secret, small objects in these materials having been found in Greece, the Isles of the Archipelago, and Italy, apparently exported from the ports of Egypt. The manufacture was continued under the Greeks and Romans, but gradually disappeared at the beginning of the Empire, a few vases and lamps of it having been found in Italy of Greek form, and with Greek subjects in relief, probably made at Alexandria; it seems to have been superseded by metallic and glass work.

The Assyrians like the Egyptians made extensive use of sun and kiln-dried bricks, especially for the substructure of their edifices, walls, houses, and tombs; their bricks were of another size, about 14 inches square by 4 inches thick. Like the Egyptian their upper surface is often stamped with the names and titles of their king in Assyrian cuneiform. The Assyrian potter was also extensively engaged in producing in clay histories, title-deeds, religious dedications and other documents on hexagonal prisms, cylindrical rolls, and small square slabs convex on both sides. On these the inscribed letters were impressed from a small punch. Many of these were impressed with seals, and even seals of baked clay added to deeds. About 10,000 fragments of an ancient terra cotta library were found in the archive room of the palace at Kouyunjik, and the preservation of the history of Sennacherib and his campaign against Judæa, as recorded in the Assyrian annals, is owing to this indestructible method of preserving public records. Like the Egyptians the Assyrians, in the 8th or 9th century, B.C., were acquainted with the art of making a fayence or enamelled ware with metallic oxides and tin and lead fluxes; and the story of Semiramis and her constructions with glazed bricks, representing subjects, is by no means fabulous. The vases and other objects of this material differ considerably in their body, which is of a yellow paste, from the Egyptian, and the ware is inferior to it in colour and elegance. The potter's art seems to have been in full activity till the fall of Nineveh, and to have been kept up till a late period in the plains of Assyria.

The arts of the Babylonians, who were contemporary with or succeeded the Assyrians, are so like that the difference is hardly perceptible. Sun-dried bricks of nearly the same dimensions as the Assyrian, found in all the ruins of the plains of Shinar, were prepared by the same process, and generally had straw. The kiln-dried bricks, mentioned in Genesis as in use after the Flood, have also straw for the sake of heating them more thoroughly, and vary in quality and colour. They are also stamped with the names of Babylonian monarchs. Some buildings, as the Birs Nimrud, now known to be a temple dedicated by Nebuchadnezzar to the seven planets, were made of stages of differently coloured bricks, each the appropriate colour of the planet. Mortar of lime and bitumen for the foundations, as mentioned in the description of the Tower of Babel, is found to have been used for cementing the brick-work together. Small cones were also used for making an ornamental brick-work. The public and private records were preserved in baked clay like the Assyrian, and bas-reliefs and small votive figures of baked and sun-dried clay, made by a mould, were used for religious purposes, and portions of the colossal statues of the gods appear to have been made of clay, plated externally with brass, or clay formed part of the figure with other metals. The glazed ware of the Babylonians was of the same character as the Assyrian. The potteries of Assyria and Mesopotamia appear to have continued in activity under the foreign rulers of that country, and the remains show local wares manufactured under Greek and Roman influence, while the use of the fayence under the Sassanian monarchs took an extraordinary development, an immense number of glazed coffins of that period having been found at Warka and Mugeyer, with other fictile remains of a late epoch. The Persians, who succeeded to the empire of the Assyrians, are only known to have used pottery, and the art of pottery must be considered at this period to have been chiefly exercised by the Phœnicians and Greeks. The first of these people, the great traders of antiquity seem to have made plain unglazed terra cotta and glazed ware like the Egyptians, and to have traded in them with the Greek islanders and the Etruscans at about the 7th century, B.C. The Hebrews do not appear to have exercised the art till after the Exodus, and probably brought it with them from Egypt, having before that period used other substances for drinking purposes, or acquired them from other people; and the very few Jewish vases as yet found do not seem older than the Maccabees, although the art of glazing by litharge was known in the days of Solomon. At the time of the Captivity the prophets often used metaphors derived from the potter's art, and some bowls supposed to have been used by the captive Jews of Assyria are evidently of a comparatively recent epoch. Fragments found in Moab have revealed a ware like the earlier glazed Greek; but the greatest advance in the fictile art was made by the Greeks.

Prometheus, according to their legends, had modelled Pandora out of Sinopic clay, and bricks, statues, and other objects of sun-dried clay were made by some of the earliest potters. Kilns were, however, in use at the earliest age, and the palaces of Crœsus, Mausolus, and Attalus show their extensive use in Asia Minor, while constructions of brick have been found at Athens and in Sicily. They were made as the Egyptian by wooden moulds, *plaisia*, and named after the dimensions: *didora* 1 foot long and 2 palms or half a foot broad; *tetradora*, 4 palms square, chiefly in use for private buildings; and *pentadora*, or 5 palms square, used in public edifices; and *Lydia*, or 1 foot 6 inches long 1 foot broad, probably those of the palace of Crœsus. Besides which a very light kind was made at Pitane in Mysia. Bricks of dimensions not described by ancient authors have been also found, and all are distinguished by their greater thinness than the Egyptian or Assyrian, resembling tiles, and made of a fine red or yellow clay. Till about B.C. 580 the temples of Greece were roofed with terra cotta tiles *keramoi*, which were said to have been invented in Cyprus, and are flanged at both sides like the Roman, the joint being covered with a semicircular tile, and the lower semicircle of the series having an upright semi-oval part called the antefix, on which ornaments were impressed in a bas-relief, the front of the antefix being faced with a finer clay for the impression; all these tiles have occasionally stamped upon them, in relief, the name of the city, the potter, and year of the magistrate in which they were made. The cornices of tombs and *naoi* or shrines of the Doric order were ornamented with gargoile heads of lions, and the invention of antefixes was attributed to the Corinthian potter Dibutades, who flourished at a mythic period. Friezes and other architectural members, and cylindrical pipes of terra cotta for draining or conveying water were also used by the Greeks. One large branch of the manufacture consisted in small figures called *pelina* clays, or *agalmata ostrakina* earthenware, used for penates or votive offerings; they were made in a mould of two pieces of a harder and more compact terra cotta, into which a crust of clay about 1-8th inch thick was pressed so as to leave the centre and base of the little figure hollow, the heads and arms were solid, and sometimes produced from separate moulds and attached while the clay was moist. At the back there is usually a large hole to allow the clay to expand or to attach the figure to a wall. After coming from the furnace these figures were covered with a coating of whitewash *leukoma*, and then painted and sometimes partially gilded. Some of these figurines are as old as the Dædalids, and they continue till the close of the Roman Empire. Larger figures of deities are of rarer occurrence, and existed in Greece in the days of Pausanias, and others, are mentioned as extant in Constantinople. This art was first applied to producing casts of statues in other materials by Lysistratus, the brother of Lysippus, and by other artists, such as the celebrated Zeuxis, who flourished B.C. 400, to model the subject of his pictures, and Pasiteles, a Greek artist, living at Rome, in the 1st century, B.C., modelled his statues first in terra cotta. Terra cotta was also used for portions of statues in toreutic work and for the moulds of objects in bronze. Reliefs or friezes of different sizes, *emblemata* for applying to other works of art, were also made from moulds and painted in the same way: cones used for the loom, or as weights for nets or drapery, dolls called *koræ*, *nymphæ*, or *neurospasta*, but with moveable hands and arms, and lamps, *lychni*, were made of terra cotta, with reliefs on the upper surface, and the maker's name on the base below.

The invention of the potter's wheel at the earliest period of Greek history described in Homer, claimed by Athens for Corœbus, by Corinth for Hyberbius, and for Dædalus or Talus by the Cretans, probably came from the East. The wheel was a low horizontal table turning on a pivot on a central foot; it was made to revolve by a boy or assistant, and extensively used in the production of vases of various shapes and all dimensions, such as saucers, *phialæ*; plates, *pinakes*; jugs, *œnochoæ*; pots, *chytræ*; boxes, *pyxides*; and even jars, *amphoræ*, in great numbers; and all vases except huge casks, *pithoi*, which were moulded on a frame. The feet and handles of vases were stamped or moulded, and fixed while wet to the body of the vase. The amphoræ of several states, about the 2nd to 1st century B.C., are stamped with the name and emblem of the magistrates on the handle to indicate the state from which they came, and the date when they were made, but they are otherwise not ornamented. [Vases.] Some of the sepulchral vases were covered with a *leukoma*, painted in colours and gilded, but these belong generally to the class of glazed vases. These vases were made of a finely levigated clay, such as has recently been found at Mon

Reale in Sicily, in the vicinity of Naples, and elsewhere; and the most celebrated clays were those of Mount Colias near Athens, Corinth, Cnidus, Samos, and Coptos. The vases were made by the same process as those of terra cotta, but are of a redder or paler clay. After they had been sufficiently dried in the sun they were painted, and the upper surface, to about ⅓rd the thickness of the vase, was faced with a finer clay to receive the colour. The figures intended to be painted were first traced on the wet clay with a tool in a slight outline, or in a dotted line, and the colours laid on with a reed formed like a brush. Some of the colours were glazed and others flat. The principal colours were fawn, maroon colour, and black, which varies from a deep jet to a deep green or leaden hue. This was made of manganese, oxide of iron, or carbonaceous substances. The other colours used, flat and not glazed, were white made of a fine pipe-clay or alumina, crimson produced by an oxide of iron, yellow ochre, blue and green oxides of copper, a light brown ochre, light red made of ground terra cotta, and a bright scarlet produced from an iron oxide. Gilding was occasionally employed, especially on the later vases. The glazed colours were mixed or covered with a siliceous or thin alkaline glaze, and the vases were sent to the furnace and baked at a low temperature, apparently without saggers. Glazed vases of this kind were manufactured in Greece, from the 8th or 9th century till the 1st century B.C., but very different in paste, style, shape, and colouring. The earliest vases contemporaneous with the heroic age of Greece, and found at the oldest sites, are of a pale clay, clumsy shape, generally of large size, and painted in light red, brown, or dark coloured ornaments of large proportions. With these are occasionally very small figures of animals, which by degrees are drawn of larger size, but still of the same thin proportions. These vases, which have no inscription, and were succeeded by others of Corinthian fabric with a pale clay, the body covered with a siliceous coating of a cream or lemon colour, the figures and ornaments painted in a dark brown, maroon, or black colour, the subjects of which were at first friezes of animals, *zoidia* of larger size and fuller proportions, with backgrounds strown with flowers. After they returned from the kiln, the potter cut with a sharp tool incised lines in the dark figures and ornaments to mark out the details and relieve the monotony of the figures, and touched up parts with a flat crimson colour. The later vases of this style have human figures introduced with animals, and *Doric* inscriptions as old as the 6th century B.C., and subjects derived from Asiatic sources, or the oldest legends: some of these vases are supposed to be late imitations, and great difference is observable in the local fabrics of Corinth, the Isles, and Italy. By degrees the potter changed the tone of the clay, introducing a pale salmon-coloured earth, and ceased to use animal friezes except in a subordinate manner; the art also improved, although resembling the Aeginæan and Selinuntine remains. By degrees this style attained its full development by the employment of a rich orange red clay, and of a dark black for figures and backgrounds, a freer use of white and red flat colours, a more finished style of art, with figures of better proportions, and the abundant use of inscriptions, giving the names of the figures represented, of the artists, potters, the celebrated beauties of the day, speeches, and exclamations. The attitudes are still, rigid, the eyes seen in profile, the forms full and muscular; the accessories, parts of the form, and of the draperies, are coloured in crimson, and the flesh of females white. There are clearly traces of two or three fabrics in these vases—of earlier ones, the most remarkable is that at Florence, the work of the potter Hergotimos and the artist Glaucythes, representing in several friezes the arguments of an epic poem, reciting the adventures of Achilles. Several artists of this style, such as Amasis, Execias, and Hieron painted with great vigour; the principal shapes are *Hydriæ*, or water vases with three handles, amphoræ with two; *œnochoæ*, or wine jugs; and *cylices*, or cups; other shapes called *cyathi* and *mastoi* are of rarer occurrence. The subjects are chiefly taken from the adventures of Bacchus, the exploits of Hercules, and the war of Troy, the contest of the gods and giants, and of the Greeks and Amazons. These vases seem to have continued until the 5th century, B.C., when a new class of painted vases were invented; the figures were traced out as in the old style, but the back ground was filled in with black colour, and the figures left the rich warm red colour of the clay; the inner details of the form were traced with fine black lines of the same glaze, to which finer lines in a brown glaze indicating those portions less distinctly seen were added; the accessories are at first coloured in crimson, but white was subsequently introduced. The art at first resembles that of the black figures, and some painters used both styles on the same vases; but by degrees, especially after the age of Phidias, B.C. 460, the art rapidly improved; the eyes are no longer oblique but represented as in modern drawing, and lashes are introduced; full faces appear, the drapery of the figures alter, the flesh of the female figures is the same colour as the male. Inscriptions are rare, but the letters of the later and completed alphabet are found. The principal shapes are *amphoræ*, *krateres*, *œnochoæ*, and *cylices*, and some varieties of cups; the *hydriæ* disappear for the smaller *kalpides*, and the amphoræ are of smaller proportions. These vases appear to have been made from 480 to about 360 B.C. Their subjects are taken from the same sources, with the addition of others from the *Nostoi*, or return of the Greeks, the Odyssey, the Oresteid, Perseid, and the Gymnasium. Many of the paintings seem to be copies from memory of the pictures of Polygnotus, Parrhasius, and Zeuxis. As the style continued to improve the figures became larger and more grandiose; and finally, of more slender and elegant proportions, with elaborate dresses and minute and finished lines resembling those of the coins of Magna Græcia and Sicily. In the days of Pyrrhus, an attempt is made at aerial perspective by groups introduced at different heights, and the introduction of undulating lines, stones, and other objects; while interiors are represented, and the pictures, as in modern art, crowded with accessories or mingled with arabesques. Some of these vases exhibit local costumes; the size of the craters, amphoræ, and larger vases transcends that of the last style; the subjects are principally those of the later myths of the Tragedians. Nearly contemporary with these vases are those having their body covered with a *leukoma*, or coating of white, on which figures have been traced in red outline and then painted with polychrome flat colours. They are principally lecythi, and used for the dead. Other vases of this class, of small size, are moulded in shape of gods or animals. The close of the vase art in Greece and Italy appears to be about the 2nd century B.C. The florid style had then degenerated into a coarse scrawl, with subjects taken from the comic stage; and at last the potters substituted moulded vases entirely coloured black with *emblemata* stamped at the handles, or painted with opaque flat colours, masks, arabesques, doves, and heads on the black glaze of the vases; some are accompanied with archaic Latin inscriptions, evidently after the conquest of Campania by the Romans. At all periods there were numerous vases entirely painted black, called *libyes*, of less value than the vases painted with figures, but distinguished by the lustre of their glaze, that of Nola being remarkably black and bright, and at the later period in S. Italy of a leaden hue. In imitation of the metallic vases, which superseded those of clay, the later ones have *emblemata* or bas-reliefs stamped in separate pieces and affixed while the clay was moist, or even stamped with figures in intaglio to imitate cups of precious stone which were engraved like gems. During the most flourishing period of the art the names of about fifty potters and thirty vase painters are known as exercising the art. The trade was lucrative, the prices on the whole being about the same as modern earthenware. These vases have been found in Italy as far north as the ancient Hadria, throughout Greece proper, and Asia Minor, to the Taurus, in the Isles of the Archipelago, and as far east as Panticapæum.

The pottery of the Greeks did not, however, enjoy the entire monopoly of the Italian market, for various kinds of wares were made in the peninsula; in the north, the Etruscans manufactured a red gritty ware distinguished by the presence of micaceous particles of a volcanic sand, and terra cotta of a red colour, into tiles, busts, statues, reliefs, and architectural mouldings. Etruscan statues in clay, called *signa Tuscanica*, were supposed to be of the highest antiquity, and decorated the early temples at Rome. The most celebrated were the statue of Jupiter Capitolinus, made by Vulcanius or Turianus of Fregellæ, or Veii, the quadriga on the acroterium of the temple, the Hercules of the Forum Boarium, and a Janus. Bas-relief friezes, made from moulds, have been found at Velletri and other Etruscan sites; and numerous sarcophagi of terra cotta, generally small, but sometimes of life size, destined to hold the ashes of the dead, and gaudily painted in tempera, and either modelled or moulded, have been discovered in the Etruscan territory. Vases of many shapes in imitation of the Greek, both of glazed and plain wares, were made by the Etruscan potters. The glazed vases, called by the Italian antiquaries national, are of a paler clay, and glazed with a black colour of an ashen or leaden hue, with subjects derived from the Etruscan mythology, accompanied with Etruscan inscriptions.

Besides these vases, the Etruscan and Sabine of the earliest period resemble in paste and texture the Scandinavian and Celtic found distributed over the surface of the European continent, distinguished by rude forms, apparently borrowed from works in wood or metal, and ornamented with studs, knobs, engraved or punctured ornaments. The most remarkable of these vases were those found near the Alban Lake, resembling the ancient *tuguria* with their pent roofs, and containing the ashes of the dead; they were found in 1817, surrounded with smaller vases, and placed inside large two-handled vases for protection, under beds of lava, and were referred to the most remote age. These vases were baked at a low temperature, and modelled as well as turned on the lathe. The black ware of the Etruscans was made of a clay mixed throughout with oxide of iron and manganese, and breaking with a black fracture; polished externally. The walls of the vases are thick in some localities and thin in others; they are ornamented with incised or punctured lines, or ornaments disposed in friezes or bas-reliefs round the body. Besides the ornaments on the body of the vase, the handles, lips, and other parts are fantastically decorated with relief ornaments, representing men and animals, in a style more ornamental than convenient, and attempting in clay to imitate the metallic work of Asia and Greece; the subjects being chosen from the oldest myths of Greece or Asiatic deities. Many vases are ornamented with friezes of small figures about one inch high made from a cylindrical stamp revolving on the clay. This ware appears to have continued from B.C. 660 to 395, the fall of the Etruscan power. Some examples have Etruscan inscriptions incised upon them, but only the names of possessors. Works of terra cotta have been discovered in other Italian sites, as at Ardea, amidst the Samnites, and at Capua, but there is nothing to distinguish them in type or design from the Hellenic art of Magna Græcia.

The pottery of Rome was probably imported from Etruria, and the earliest ware was the black Etruscan. Numa, indeed, is said to have founded a guild of potters, B.C. 700, but the oldest known Roman vases are saucers or phialæ of red clay, coloured with a leaden black glaze, ornamented with white figures and inscribed in painted white letters *Volcani pocolom, Lavernai pocolom,* the cup of Vulcan, the cup of Laverna, &c. These were probably made in Campania, about B.C. 200, after the conquest of Southern Italy by their arms. The old potteries of Rome are by no means distinguishable from their neighbours, and they probably imported Greek, Etruscan, Campanian, and other wares for all but the commonest and roughest usages of life. Old Rome, before the rebuilding of the city by Augustus, who boasted that he had found it of brick and left it of stone, was built of brick houses. The Roman brick was made of the same shape and dimensions, and in the same manner as the Greek, and Vitruvius calls them *Lydia, pentadora,* and *tetradora.* The usual dimensions are 15 × 4 inches superficial, and 2 inches thick, and they rather resemble tiles than bricks; but some, in dimensions like the modern bricks, are seen in the Meta Sudans at Rome. The paste of the Roman bricks is of a close, compact, and fine texture, remarkably hard and sonorous when struck, and is of a dark red or straw colour. They often bear traces of the feet of boys in hob-nailed sandals, goats, dogs, and other animals which have walked over them while drying in the kiln, and have inscriptions incised upon them, sometimes alphabets traced by boys, poetic effusions, the dates when prepared, and the purpose for which made. Tiles, *tegulæ,* are distinguished from the bricks by their flanged edges, *hamatæ,* and were made by the same process; they were covered at the joint by a semicircular tile, *imbrex,* the end imbrex of the series terminating over a semi-oval upright, called the *antefixum,* on which was impressed in bas-relief an architectural ornament or figure of a deity; the cornices also of terra cotta had gargoiles in shape of the head or forepart of a lion. The paste of the tiles is similar to that of bricks, but their dimensions differ; they are 1 foot 3½ inches in length by 1 foot wide, and 2½ inches in height in the flange, and are named according to their sizes *bipedales,* or two foot; or *sesquipedales,* or 1½ foot tiles; some are slightly convex, and sometimes more convex, and at the Byzantine period, some of the roofs seem to have been gilded. Besides for roofing they were used for the floors of the hypocausts, *suspensoria,* or low storied houses, *attegia, tegulicia,* and graves; flue tiles or pipes, *tubi,* scored at the sides with a hackle or comb, fixed with a small nail of lead, *clavis muscaria,* were used for heating winter apartments or conveying the smoke from the furnaces of the hypocausts; wall tiles, *bipedales,* with various ornaments; cylindrical drain tiles, *tubuli,* sometimes hemispherical and open, above 8 inches diameter. Fragments of bricks and tiles were used for the *ruderatio,* or understrata of roads, and for the red *tesseræ* of mosaic pavements. The brick and tile makers, *teguli ab imbricibus, tegularii,* stamped on the tiles inscriptions in bas-relief letters. Those on the Roman tiles often are circular medallions with a device, the name of the fabric, *opus doliare,* or "pot work," the consuls when made, the farms, potteries, *officinæ, figlinæ, doliares officinæ.* These inscriptions commence about A.D. 100, and end A.D. 222. When the tiles were made by the military, the *decurio* of the workmen stamped on them the name and titles of the legion, cohort, or other military division by whom they were made, in an abridged form. Other portions of architecture, especially friezes with mythical and other subjects in flat bas-relief, affixed by leaden plugs or nails to the impluvium, and painted in gay colours in *tempera,* were also made of a terra cotta like the bricks. Much care was bestowed on this branch of the fictile art, and the times specified for their fabric in spring and autumn, and Hostilius Saserna the elder and younger, two writers on agriculture, had, according to Varro, written on the subject of the potteries. Although the Romans imported under the republic statues from Etruria, at a later period they were made in the Roman territories; the principal statues of this material at Rome were a Felicitas, made by order of Lucullus, and a Venus Genetrix for Julius Cæsar; in later times terra cotta statues were gilded. Few figures of large size have been found at Pompeii, Pozzuoli, near the Porta Latina at Rome, and at other places.

Throughout, however, the Roman empire, small figures of terra cotta called *sigilla* or *sigillaria,* used for votive or religious purposes, for presents on the festival of Saturnalia, some representing deities, others personages of common life, or grotesque figures like modern toys, which were also called *crepundia,* were sometimes made of terra cotta, by particular potters, *sigillaria* or *signarii.* A pottery for the manufacture of these figures with moulds has been lately found at Moulins, and in the valley of Allier; others of the Gaulish goddess Nehallenia have been found at Autun, Dijon, and a few in England. They are generally of a white or pipe clay, and rarely have a potter's name. Terra cotta was also employed for miscellaneous uses, such as the crucibles and moulds of the false coiner, and great quantities of lamps, *lucernæ,* were made of this material. These were stamped out of moulds, *formæ,* by potters called *lucernarii;* the body is generally of a circular shape, with one or more projecting nozzles, and the handles in shape of lunes, busts of Serapis, antefixal ornaments or plain rings. They are generally only a few inches long, and slightly concave on the upper surface, on which are stamped, in bas-relief, deities, animals, fables, subjects taken from the poets, the games of the circus, and amusements of the streets. At a later period in the empire, the Jews or Christians used as a device the golden candlestick, the monogram of Christ, and other religious devices. These lamps have generally on their base letters stamped in, either the name of the potter, and potteries, or the place and date. The principal lamp-makers lived at the Porta Trigemina, situated at the foot of the Aventine, and towards the Tiber, where Cacus the robber giant had dwelt, close to the Salt Springs or Salt Pans, and on the Vatican. The trade was active, and the lamps appear to have been imported throughout the empire. Besides the normal type, some fancy shapes occur, such as a pair of feet and a gladiator's helmet. Lamps were in great use for household purposes, illuminations, funerals, and votive offerings. Notwithstanding the introduction of metallic vases in the latter days of the Republic, the Romans, especially the poorer classes, made various kinds of earthenware vases for all household and some religious purposes even during the Empire. Large casks, *dolia,* made of a coarse red, white, or yellow clay, and 7 or 8 feet high, hooped with lead, were made by particular makers called *doliarii,* and used as vats for holding wine; they were made in the same manner as the pithoi, and they gave the name of opus doliare to earthenware. The Roman potters used the wheel and moulds for the production of other vases, and kilns of potters have been discovered in Germany, France, and Britain with vases, remains of materials, and tools. The principal vases are the unglazed yellow used for amphoræ, lagenæ, bottles, a flat vase with a spout called the *mortarium,* and many small pateræ; cups and bowls, bottles, cadi, gutti, ollæ or jars, cups, calices, mortars, and sometimes amphoræ were often made of a pale red ware, the paste mixed with a small quartz pebble; a kind of gray ware made of a sandy loam, resembling stone ware, was used for mortaria and amphoræ; small plates, *patellæ,* cups, *pocula,* or *ciboria,* stands for vases, or candlesticks, *cerulæ,* were often made of unglazed black, ornamented with engine-turned, or thorny, or scaly ornaments; this ware is of late period, and probably succeeded the other ware about the 3rd century A.D.; a few vases of small size for the table have been found of a brown ware, and a class of small vases with egg-shaped bodies and tall necks—the ancient phials.

At the close of the Greek vase art, the paintings had entirely disappeared; the vases entirely coloured black, being ornamented with subjects on relief in imitation of relief ornaments, *crustæ* or *emblemata,* of metallic vases, and vases of this class appear to have been made in black and red glazed ware at Cuma, Capua, and Aretium. This ware, the finest produced by the Roman potteries, and apparently commencing about the 1st century B.C., was called Samian by Plautus, and the writers of the close of the Republic, but Campanian by Horace and writers of the Empire. Vases of this class have indeed been found in the Greek islands, and may have thence been imported originally to Rome, but the chief site of the fabric was in Aretium, whence it is frequently called Aretine ware. It is distinguished by its close compact paste of a bright red coralline colour, breaking with a fracture like sealing wax, and glazed externally with a mere polish or very thin siliceous glaze. The vases are of small size chiefly bowls, *trullæ,* cups, *calices,* bottles, *gutti,* flat, circular, or oval dishes, tureens, either plain and turned on the wheel, or else ornamented externally with subjects in bas-relief, and made from moulds. These moulds were made of a hard compact and pale red clay, and the subjects were produced from moveable types of hard clay set up into compositions and stamped on the moulds. The subjects are taken from Roman works of art and mythology, the principal buildings and statues of Rome, gladiators, amusements of the circus, and erotic scenes, or arabesque and floral ornaments. The subjects are arranged in one or more friezes round the vase, and fill up the external surface. These vases are impressed with the names of above 500 potters, some of Gaulish origin, showing that the red ware was manufactured in France and Germany. In the plain vases the names are stamped on the inside of the bottom, while on the vases with bas-reliefs on tesseræ with letters in relief; the names of the potters are preceded or followed by the expressions M (anu) by the hand, OF (ficina) the establishment, F (ecit) he made. The majority are slaves distinguished by their single names, but the single names of freedmen or free proprietors appear on some specimens. The potters were called *figuli* or *figulinarii,* as makers of vases *fictiliarii,* and *vascularii* and *ampullarii* or pot makers. The merchants who dealt in the ware were called *negotiatores artis cretariæ:* traces of their manufactories and shops have been found at Nancy, Paris, Nismes, Lyons, Clermont, near Bourdeaux, Rheinzabern, Heiligenberg, and Mayence; while the ware has been found as far east as the Crimea, and west, as the W. coast of England, and distributed throughout Italy, Greece, Asia Minor, the Islands of the Ægean and Archipelago, and the confines of the Roman empire. There is a great difference in the ware; that of the 1st century B.C. from the potteries of Campania being of finer earth and glaze, ornamented with relief sometimes delicately executed. In Northern Europe, that made under the first Cæsars is of the finest colour, brightest glaze, hardest paste, and best executed ornaments. Under Vespasian and his sons the paste is good, but no longer fine, and the vases resemble imitations of the earlier ware. At the time of the Antonines, A.D. 120, true Samian is no longer found, the shapes are still good, but the fracture and glaze are coarse, and coloured with red lead, or sulphate of iron, and an inferior glaze. After the age of the Antonines, the decadence is still greater, the colour and glaze of the false Samian much worse. From some of the figures the art appears to have been continued to the 4th century A.D. Some of the later vases are decorated with relief ornaments *à barbotine*, produced by squeezing the clay when moist out of a pipe or spoon, and modelling it into the required shape with a tool. Vases of this ware have also patterns cut with a sharp tool out of the body of the vase, in imitation of the diatretum or engraving on glass. The principal sites in Italy for celebrated vases under the Empire were Aretium, Allifæ in Samnium, celebrated for its cups, Pollentia, Surrentum, Modena and Rhegium, besides those already mentioned. A few vases of lustrous black ware were made by the Romans, but the red Samian or Roman ware seems to have been succeeded by a glazed black ware, probably as early as the 3rd century in Gaul and Britain, made by the native potters. These vases are of various pastes, made by the wheel, but often decorated with subjects *à barbotine*, consisting of gladiators or hunting scenes and ornaments punctured in or incised. The principal sites of the fabric were at Castor and the Upchurch marshes near Sheerness, and at Crockhill in the New Forest; the paste of this last is made of a dark gray clay, and the surface covered with an alkaline maroon glaze; the Castor ware was made of a gray clay, and the external colour is supposed to have been produced by condensing the smoke of the kiln on the vases while baking; the Upchurch ware is made of the London clay with an external black glaze or polish, that found at Crockhill was made of a local blue clay covered with an alkaline maroon glaze. Small vases, principally drinking cups, with corrugated sides, were made of this ware. Similar wares, but occasionally impressed with the names of potters in relief, have been found in France and Germany; and a black glazed ware with a red paste, having in slip of pipe clay such expressions as AVE hail, BIBE drink, DA VINVM give wine, in the shape of jugs and bottles, and perhaps as late as the 4th and 5th centuries A.D. Besides these imperfectly glazed vases of a tender lustrous pottery, the fabric of an enamelled or glazed terra cotta, covered with a thick siliceous glaze, in some instances produced by hand, seems to have been handed down in Egypt, and the products in the shape of lamps and jugs imported from Alexandria throughout the Roman world, a fact important to be remembered in the history of the revival of glazed ware in modern Europe.

The aboriginal natives of northern Europe, the Celtic, and Teutonic, and Scandinavian races, had from the earliest period a rude pottery, consisting of coarse vessels of clay, of rude construction, with open mouths, thick walls, made of a paste of clay mingled with small pebbles, and imperfectly baked in rude furnaces by means of wood, straw, or weeds. This ware, more or less brown or gray, is found in the lowest stratas of human remains, the tumuli of the races which used stone and bronze weapons, and in the oldest cromlechs. It was not made on the wheel, but fashioned by the hand; and the ornaments imitate the rude tattooing of the natives, and the decorations of their jewels, consisting of hatched bands, chevrons, zones, and other designs, either impressed by twigs or rushes. These vases, known to the Romans as *bascaudæ*, or baskets, and imported to Rome, hold the ashes of the dead; some few are of small size, and all appear to have been employed for household purposes. They exhibit great local differences, and some of the most remarkable are those in shape of ancient houses found at Chemnitz in Thüringen, at Roenne, in the isle of Bernholm, and at Parchim. These native wares appear to have never been entirely superseded by the Roman wares amongst the Northern races; and the Germans and Anglo-Saxons, Scandinavians and Gauls, under the first dynasty, manufactured a kind of ware of a dark paste, imperfectly baked, or even sun-dried, and in the shape of jars, ornamented with impressions from bone or wooden stamps, representing fleurettes, crosses, triangles, and other ornaments, disposed in bands or rows round the neck of the vases. The use of glass, horns, wooden cups, and jugs of perishable materials, caused, however, the disuse of smaller vessels of earthenware. After the fall of the Roman empire, the working of terra cotta disappeared with the decline of the arts, and only reappeared with their revival. Large and remarkable pieces, as that of S. Antony, were executed, however, by Nicolo of Arezzo, in the 14th century, for his native town; and in the 15th, Simon made a Magdalen of heroic size for Florence. Celebrated works of Mazzoni Guido Paganino of Modena, and Belsa of Florence, are still seen in that town, Venice, Ferrara, and Naples; and in Spain, in the 16th century, Miguel made colossal statues of St. Paul and St. Peter, for the cathedral of Seville; and Germain Pillon, in France, at the close of the same century, executed colossal religious works. During the 18th century, however, only coarse figures for gardens seem to have been made of this material. At the close, however, of the last century, the art had considerably revived, both for sculpture and architecture; and in France, both Clodion and Mène executed works of merit in this material. The application of terra cotta to buildings and sepulchres has had, however, a greater extension, and the buildings of Toulouse, Dresden, Berlin, and Munich, the churches and other edifices, are often enriched with terra cotta reliefs and other ornaments. The use of bricks, which it is scarcely possible to conceive can have been entirely lost, is said to have been re-introduced into England by Alfred in the 9th century, but according to the best authorities does not date earlier than the 14th century.

The manufacture of a soft fine pottery, and of a coarse pottery unglazed by plumbiferous or stanniferous glazes, seems to have prevailed all over the habitable globe. Great jars, imitated from the ancient dolia, are still made in the Puy de Dome, in France; near Florence; in Spain, where they are called *tinajas*; in Armenia, named *koupahina*; by the Bushmen of Africa; the Javanese; the Guaytokares, or old Indian tribe of the Corroados, on the banks of the Paraiba, in Brazil, where they were employed to hold the bodies of the dead. Smaller vessels of unglazed earthenware, for common purposes, are now made all over Europe. One of the most extensive classes are the water coolers, a kind of bottle of porous clay, called *alcarazza* in Spanish, *alcaradza* in Portuguese. Spain is particularly celebrated for their manufacture, which is said to have flourished as early as A.D. 304, and they are still made in Valencia and Andalusia. The principal Asiatic pottery of this class is stated to be the fine red ware of Anatolia, that of Broussa, the yellowish white of Mecca, the red coffee-pots of Has in Yemen, the red clay pipe bowls of Sana, the water bottles of white ware of Cora in Persia. In India the character of the ware resembles in its type that of China; Chandranagore, Pondicherry, and Kanial manufacture red and brownish lamps for pagodas; at Calcutta the ware is reddish brown and micaceous. The pottery of Cochin China is fine, hard, light, and turned; of Manilla, white and turned, with another fabric introduced by the Spaniards. Ceylon produces spheroidal vases, of a red paste; Java, red turned pottery; Sumatra, at Palembang, water coolers of a pale reddish-brown ware. Manfaloot, in Egypt, makes great jars of yellow clay for holding indigo, and *selah mograbby*, or white water coolers of Marocco, the *zyr* or common jars, and at Khenneh in Upper Egypt *bardachs* or water coolers, of a thin yellowish ware, are made in such abundance and so cheap as to be seldom used twice. Algiers and Tunis produce a whitish pottery, thin and turned; and that of the Nigritic tribes, in the centre of Africa, chiefly from Kana, is either of a pale reddish-brown with coatings of red or white colour, or else of a black colour, feebly baked. At Madagascar the pottery is of an ashen gray and micaceous paste, sometimes with black anthracite bands.

The aboriginal pottery of America resembles in its general characters, the rudeness of its type, ornamentation, and baking, that found in other parts of the world. That found in the northern states, in the tumuli at St. Louis, near the river Merrimac, in Ohio, in Louisiana, Virginia, and Tennessee, has its paste often mixed with the shells of the Myas anodonta, and is ornamented with lines and hatched marks. These potteries are of the rudest kind; those of the Toltec and Aztec nations, which are found in Mexico, show greater artistic merit, and are principally of red ware, ornamented with native patterns in white pipe-clay, sometimes modelled in various shapes, and decorated with modelled ornaments of figures of deities and other objects, occasionally covered with a siliceous glaze. In terra-cotta figures of deities the natives particularly excelled, and have retained the art, modified by Spanish influences, to the present day. In Mitla, Palenque, and Copan, many objects of various kinds, in terra cotta and soft pottery, have been discovered. The pottery of Mexico at the present day is described as peculiar, of a dirty white, pearl gray, reddish yellow, or black colour, light, and sometimes reddened with ochre, never made by the wheel, but decorated with ornaments of a black colour, and similar to that of the Antilles and Martinique. The ancient potteries of South America resemble in their general characteristics those of Mexico; in the *huacas*, or tombs of the ancient inhabitants of Peru, especially those near the Lake Titicaca, vases, principally water bottles, of a fine red clay like the Greek, or a dark clay like the Etruscan ware, are found in numbers; they are light, always made by the hand, never by moulds or the wheel, but often are modelled with considerable skill and taste in shape of human heads, men, and animals, and decorated with ornaments resembling the Greek meanders, or with animals on the body, and handles. Some resemble the Chinese, especially certain vases with a gourd-shaped body and bifurcated necks; and many with double mouths, when blown into by the mouth, give forth a whistling sound. The potter's art was exercised by all tribes of the continent except the natives of the Pampas. In Brazil the ware is of a red or black colour, modelled in shape of fruit or animals, and coated with an unctuous varnish. The modern ware of Peru differs from the ancient, but still retains a local character. At Lima and Callao a red pottery, covered with an ochreous coating, and a blackish ware, all hand-made and feebly baked, is manufactured, along with a coarse red pottery at Itaty. North of Corrientes coarse black *tinajas*, in imitation of the Spanish, are made. The ware of Chili resembles that of Peru; that of Paraguay is black.

The Moors are supposed, on the conquest of Spain, A.D. 711, to have introduced into Europe the use of glazed tiles from Asia, similar tiles having been found in the mosque at Medina, A.D. 707, and in the early churches of Pisa, Pavia, and Sicily; but none of these tiles *azulejos*, found in the Alhambra, appear to be earlier than A.D. 1300, and are made of a pale clay covered with a white enamel, on which a pattern has been stamped or painted in blue and brown, and covered with a stanniferous glaze. Three classes of plates and other vessels of a fayence enamelled with white or yellow ground, on which are shields of the kings of Spain, cyphers, arabesques, and ornaments, are supposed to have been made by Moorish potters from the 13th to the 15th century. They are distinguished by the cupreous iridiscence of the glaze. But enamelled vessels, of a date even earlier, have been found in England, either the works of English or foreign potters. The principal sites of Spanish pottery were Talavera, Valencia, and Traña in Andalucia.

The custom of bringing home enamelled plates, *bacini*, by the Crusaders, and the conquest of Majorca by the Pisans in A.D. 1115, introduced the tin glazes into Italy, which are supposed to have been first used by Lucca della Robbia, A.D. 1415–1420, who made scriptural subjects in high relief; and tiles of glazed ware, principally white, although other colours, as yellow, blue, green, and violet, were also used by him and his family till A.D. 1560. The name of *Majolica*, from the island whence it had first come, and of *Raffaelle*, from the great artist who supplied some of the designs, has been given to this ware. The early kind from A.D. 1540 to 1560, called *mezza majolica*, ornamented with arabesques, coats of arms, busts, and portraits, is distinguished for the brilliancy of its colour and the iridescence of its madreperla glaze, the ruby tint being peculiar to the products of Pesaro and Gubbio, and supposed to have been invented by Maestro Giorgio. The *porcellana* or finer ware subsequently introduced is remarkable for the excellence of its paintings made from the designs by Raffaelle, Marc Antonio, and others, of scriptural and classical subjects, in light but harmonious colours. The ware declined from 1560, and in 1574 the ducal establishment of Urbino was suppressed, the art having been up to that period fostered by the dukes of Urbino. This ware was introduced into Faenza, Forli, and Rimini. The principal shapes are the *piatti di pompa* or plates, but flasks and bottles for the ducal spezieria, and pilgrims' bottles were also made. The subjects are often accompanied by explanatory inscriptions, the objects, date of vase, and initial of the potter, being generally placed on the back. The principal artists were Maestro Cencio and Orazio Fontana. The ware continued to be produced in Italy at Naples, Castelli in the 16-17th century, and at Siena, Savona, and Urbania, till the 18th century.

The manufacture of Majolica was introduced into France by Catherine de Medici, A.D. 1590, and flourished at Avignon, Nevers, St. Cloud, and Rouen till the close of the 17th century; but the ware peculiar to France was that of Palissy, invented by the celebrated potter of that name at Saintes, A.D. 1555, who from beholding an enamelled cup of Majolica or Nuremberg, after many years of laborious and unsuccessful experiments, made vases of a gray paste covered with a hard enamel and painted with bright and varied colours, chiefly cold in tone, and ornamented with fish, reptiles, flowers, and other objects, moulded from nature, found in the vicinity of Paris. His principal works were dishes, pièces rustiques, thus ornamented for sideboards, stands or basins, tiles, dishes, and jugs ornamented with religious and other subjects in relief. The art was continued by his family, but with less taste and excellence. Besides the Palissy ware a peculiar fayence called that of Henry II., consisting of a glazed hard paste of pipe clay covered with a transparent glaze, appears to have been made about that period in France. It is peculiar for stencilled patterns of mixed colours, with a predominance of yellow ochre, often with moulded figures, while encaustic tiles similar to those made in England were manufactured in France in the 13th century, and a glazed ware is supposed to have been made at Beauvais in the 14th century.

In A.D. 1278 a glazed ware is said to have been made in Alsace; and in the 15th century Ratisbon, Landshutt, and Nuremberg produced vessels with a green glaze. In A.D. 1503 Majolica ware was introduced into Nuremberg, and flourished chiefly in Franconia till the 16th century. Tiles of this ware were made till the middle of the 17th century; the same kind of ware of coarse and bad paste was made at Strasbourg and Frankenthal, and a very fine ware of this kind was produced at Höchst, but the style was abandoned in the middle of the 18th century for porcelain. At Cologne and Mansfield a fine clear paste with thin enamel, and at Wagram, and in Hungary, majolica, was manufactured. A fine enamelled ware is still said to be made at Popplesheim. The German ware is very different from the French and Italian in style and colour and shape, which are quaint and peculiar, chiefly of floral designs: animals were often moulded for drinking cups. In A.D. 1310, Delft in Holland is said to have manufactured pottery, and during the 14th and 15th centuries produced vessels and enamelled tiles. After the separation of Holland from Spain towards the close of the 16th century, A.D. 1579, the potters copied with great success the shapes, drawings, and glaze of Japanese porcelain, and produced an imitation of oriental, which from its thinness, lightness, and cheapness commanded the European market till the beginning of the 18th century, but rapidly declined in the 19th, having been superseded by the English. Chinese porcelain was also imported into Holland and England. Like the French and Italian wares the Delft has the initials or monogram of the potters placed on it. In Holland and Flanders also were manufactured in the 16th century jugs of stone ware with a bearded head in relief on the neck and coats of arms on the belly, nicknamed gray-beards or Bellarmines, in derision of the Cardinal, and of a gray or mottled brown colour; and were made in Holland and at Cologne, and a fine kind of tankard called Jacobus Kannetje, of an unglazed yellowish paste, stamped with reliefs from copper moulds, were fabricated on the lower Rhine and in Holland by the celebrated Jacqueline, Countess of Hainault, A.D. 1433. This stone ware was glazed by salt, and some of the blue vases are the finest products of the German potteries, which flourished till the beginning of the 17th century, and are known as the Flemish stone ware.

The earlier Anglo-Roman and Saxon vases of England appear to have ceased prior to the Norman invasion, the Saxons having extensively used horns, leather bottles, glass vases, and other materials; but the manufacture perhaps revived under the Plantagenets. The earlier English pottery consists of encaustic tiles of red brick, with relief, sunk or inlaid or laid on patterns, used only for religious edifices, in the latter part or the 12th or beginning of the 13th century; the oldest ornamented with heraldic bearings or badges, those of 13th-15th, with elegant foliage, and arranged in sets of single tiles of 4, 9, or 16 to the set, with heraldic bearings, mounted knights, grotesques, and inscriptions, till they were superseded in the 16th century by Flanders or gally tiles of foreign manufacture. Tiles of all these classes have been found in the principal old religious edifices of England, and appear to have been made in potteries attached to the monasteries, kilns having been discovered at Bawsey near Lynn, Droitwich, Malvern, and Saredon, some built of semicircular arches separated from each other by a massive pier.

In manuscripts of the Norman period earthen vessels are represented, and the *cruskyn* or *cruske* is mentioned as early as A.D. 1324, and in works of the 14th century, the *godet* or *godette* about the same period, the *costrel* or flask, hung by a strap to the side, and *tygs* or cups. The accounts of the executors of Eleanor, wife of Edward I., mention a payment for pitchers to Juliana the potter; but her name appears to be foreign, and it is uncertain whether they were not Flemish; in A.D. 1446, the accounts of Sir T. Howard contain orders for payment to the potters of Horpesley for earthenware jugs, and so do those of Edward IV., and in 1512 they were in use in the household of the Earl of Northumberland, and continue to be mentioned till the close of the 16th century.

The existence of early English potteries has been proved by the discoveries of moulds as old as Edward III., and of jugs, pitchers, costrils, and other vessels at a depth, and under circumstances showing that some must have existed as early as the 11th century. They are made of a coarse brittle brown paste, covered with a black or green plumbiferous, or leaden glaze; some of the most remarkable are wine or water pitchers, moulded in the form of Norman knights of the time of Henry II., or with heads of that of Edward II. This ware was continued till the commencement of the 18th century, and often has dates in the 17th century; a late pottery of it was at Wrotham. As early as the beginning of the 17th century Dutch potters are said to have established potteries of Delft ware at Fulham and Lambeth, and wine pots dated 1642 and the following years, and other vessels of this ware, are known till the close of the 17th century. Delft was made at Liverpool about the same period, and at Lambeth till a late period, but during these centuries, stone pots or Bellarmines, from Flanders, were extensively imported, although this ware appears to have been made in England at the time, while porcelain, mentioned as early in France as 1370, in the reign of Charles le Bel, began to be imported into England in the reign of Henry VIII. and Elizabeth, in 1587, and was later called China, and came from Venice; a heavy duty was laid upon it by Cromwell. But the chief seat of the English potteries was in Staffordshire, at Burslem, where coarse culinary vessels of red, brown, and mottled pottery were made. It is here that in 1670 were made the butter-pots of cylindrical shape, and of sufficient capacity to hold 14 lbs. of butter, the size and quality of which was regulated by an act of parliament. The vicinity supplied various clays suited for the different wares, and a lead glaze was obtained by the use of galena, or sulphate of lead. In 1680, salt glazing was accidentally discovered. In 1685, white and brown stone ware was made from local clays, and Crouch ware in 1690, glazed by salt and red lead. In the same year the Elers, brothers, of Nuremberg, established themselves at Bradwell, and attempted to produce an imitation of the red Japanese ware; but their secret having been discovered by Astbury, they removed to Lambeth or Chelsea in 1710. Astbury, who at first produced red ware, afterwards made a white dipped, or white stone ware of Bideford pipeclay and Shelton marl, and in 1720, the use of flint was discovered, and slip kilns for boiling the clays; and plaster of Paris moulds were subsequently introduced. Improvements in the working of the clay were made by Booth about 1750, but the great stride in the potteries was made by Wedgwood, who produced an improved *cream* ware in 1759, which was named *Queens* ware, after Queen Charlotte. From 1760-62, he invented six different kinds of ware; he was the first to introduce a classical style and fine modelling, by the aid of Flaxman, into the art, and showed as much taste in the moulding of his pieces as excellence in the ware, which, made of the fine grey marl from under the coal strata, produced a material uninjured by the vicissitudes of temperature, of a cane colour, and at first ornamented by a rude border, was subsequently covered with a pattern; he also made terra cottas, basalt, jasper, granite, and onyx wares, especially plaques, medallions, and works of taste and vertu of a blue jasper ware, with white figures in relief, which obtained a great European reputation. As early as 1767 the discovery was made of applying printed designs from copper-plates to pottery, which was thus decorated at Liverpool by Carver and returned to Burslem. Sarah Elkin, a servant of Wedgwood, first discovered a successful method of gilding earthenware, and J. Hancock, about 1800, used a process resembling water-gilding for the same purpose.

Although Cornish clay was introduced into the Staffordshire potteries, the manufacture of hard porcelain is said to have been restricted to Plymouth and Bristol, and only flourished there for a short period. Towards the close of the last century, felspar was first introduced into the Staffordshire ware by Spode. Bones or phosphate of lime were first used about 1800, and made an important change in the manufacture of soft porcelain.

At Lambeth, the site of early pottery, delftware continued to be made till recently, and stoneware is still made at Lambeth and Vauxhall; potteries also existed at Fulham, Bristol, and Leeds, in the 18th century, and at Liverpool from 1674 chiefly of delftware, where, in 1753, Sadler and Green first employed printing upon pottery; and Chaffers here established a manufactory of white earthenware; and another potter, Pennington, in 1760, produced a very successful blue colour, and imitations of oriental vases. The principal pottery here in later times was the Herculaneum, established in 1794, and continued until 1841, which produced China of a peculiar character, and stamped with the name of the manufactory. At Lowestoff a pottery was commenced in 1757, but abandoned forty years afterwards; and another existed at Nottingham in 1641; and at Sackfield a pottery was established for stoneware in 1713, but ceased about 1800; and an obscure pottery was set up by one Place, at York.

Similar to pottery, but technically distinguished from it by its unchangeability under extreme temperatures, its translucency, and its superior hardness, is the material called *Porcelain*. The term is of uncertain derivation. The material, invented by the Chinese, consists of kaolin or alumina, and pih-tun-tze or silex, which according to the proportion in which they are mixed form a hard or soft porcelain. It was invented at Sinping in China, in the time of the Han dynasty, between B.C. 185-88, made considerable progress in the 3rd century, A.D. under the Wei, and a blue kind was made at Tunggaon in the province of Chekeang, under the Tsin, who commenced A.D. 265, and continued till A.D. 419; subsequently under the Chin, A.D. 583, the celebrated potteries of Kingtechin made porcelain for the imperial court. The colour varied according to the dynasties, blue, green, and white in turns prevailing. Porcelain was also manufactured in A.D. 954 in Honan, in A.D. 960-1279 in Soochow, and in the city of Tingchow in Pihchele. Crackle porcelain was first made at Soochow, and the other localities produced different colours and patterns; but the principal site was Kingtechin, which, commencing in A.D. 581, has continued till the present day. In A.D. 1506, foreign cobalt was introduced, and about 1573, the delicate eggshell-ware was invented.

Marks are found upon Chinese pottery, sometimes animals or objects, at others inscriptions, principally imitations of seals stamped upon books in vermilion or blue with seal characters. The oldest date known is that of Hungwoo, A.D. 1368, and the practice has continued till the present time. The principal varieties of Chinese porcelain known to Europe are the pure white, the blue and white, or Nankin, the Soumali blue, the Celadon green, the marbled or shot, the citron or imperial ware, the ruby blue or brown. Besides porcelain, the Chinese extensively manufacture and use a terra-cotta, and unglazed and enamelled earthenware. The manufacture of porcelain was introduced into Japan, B.C. 27, and the potteries are situated at Imari in Fizen, and at Firose. The porcelain is whiter, of better quality and style than the Chinese: but in other oriental countries it appears doubtful whether hard porcelain was known. As early as the 8th century, the Chinese carried their wares to the coast of Arabia, and in A.D. 1154, porcelain is mentioned by Edrisi. In the 13th century, Marco Polo describes the manufacture, and in the subsequent centuries it was exported to Barbary and Florence, but the first regular importation was by the Portuguese in 1518, and an extensive trade was carried on by the Venetians, Dutch, and English. Its first appearance in this country was A.D. 1504. The passion for collecting China appeared in Europe at an early period of the 16th and 18th centuries: Charles V. in 1541, presenting a set to Maurice of Saxony; Louis XIV. ordering services of porcelain from China; Mary the wife of William III. of England collecting China; and Frederick Augustus of Saxony in 1717 founding the collection of the Grüne Gewölbe at Dresden. In England the passion still continues, immense prices being given for fine specimens of ancient Chinese porcelain. Two hundred years after the importation of porcelain, Böttcher of Berlin, in 1715, produced a perfect white porcelain at Meissen, near Dresden, in the reign of Augustus II.; his first attempts produced a red stoneware like jasper, or with a glazing of brilliant colours, and Chinese patterns; but under subsequent management, Höroldt in 1720, and Kandler, a sculptor, in 1731-56, improved the paintings and shapes; grotesque modelled figures and ornaments in the floral and rococo style were extensively manufactured. The art, although guarded with jealous care, was soon carried over Germany; Stöbzel, a foreman of the Meissen establishment, fled with his secret to Vienna in 1720, and established a fabric which differs in glaze and thickness from Dresden. Other manufactures were set up in Bohemia, and in Hungary; Ringler, a workman of the Vienna factory, carried the secret in 1740 to Höchst, near Mayence; and the establishment rose to repute under Melchior, a modeller. Busch, a Saxon, established it at Keltersbach; in 1750 Bengraf, a Höchst workman, worked for the Duke of Brunswick at Fürstenburg; Ringler also set up a manufactory in 1755, at Frankenthal, which continued until 1800; and lesser establishments arose at Nymphenburg, and Baden, and Ludwigsburg. At Berlin a private establishment, set up in 1751, was subsequently purchased by Frederick the Great, and attained an excellence and eminence which it still retains. Other porcelain manufactories also flourished in Hesse and Thuringia; and were also introduced into Russia by the Empress Elizabeth, in 1751, at Twer and Korsec. In Holland, at Amsterdam and the Hague, and at Arnheim, unsuccessful attempts to manufacture porcelain profitably were made; and at Copenhagen, at Zurich, and at Nyon on the Lake of Geneva, with better success.

The introduction of porcelain into England created the soft porcelain. The history of the earliest manufacture is involved in much obscurity. A manufactory established at Stratford-le-Bow was abandoned in the early part of the 18th century, having been probably established in an early part of the 17th century. The specimens were painted and modelled by Frye, Moser, Bacon, &c. At Chelsea, the porcelain or *gomroon* ware, as it was then called, was made earlier than 1695. At first it imitated, in its blue and white patterns, the Chinese or French models; but George II., the Duke of Cumberland, and others, procured superior means of manufacture from Germany, and under the management of Spremont it attained great excellence; but the potteries were abandoned in 1765. The vases were modelled by foreign artists in forms resembling Dresden, and painted by first-rate painters, while a fine claret colour is said to be peculiar to this fabric. Many of the drawings are very beautiful, and the vases realise immense prices. On the abandonment of the Chelsea works a factory was subsequently set up at Derby, where the moulds, workmen, &c., had been transferred, but has since been discontinued. Those of Worcester, founded by Dr. Wall in 1751, who is said to have invented the art of printing upon porcelain, not only attained, but maintain great excellence. At first they imitated the Chinese, then the Sèvres and Dresden ware and fancy ornaments. Rockingham, established in 1757, is best known for its brown or chocolate ware. At Colebrooke Dale in 1756, at Nantgarrow in 1813, and at Leek in Staffordshire, minor establishments of porcelain have flourished. The manufacture of hard porcelain in England, commenced by Cooksworthy at Plymouth in 1705, and subsequently transferred to Bristol in 1776, was abandoned since that period, till revived by the late Mr. Minton in 1850.

The soft porcelain of France was manufactured at St. Cloud as early as 1695, and was succeeded by that of Vincennes in 1740, which attained great perfection and modelled bouquets of great beauty about 1754; but two years afterwards it was removed to Sèvres, under the patronage of Madame de Pompadour. In 1768 the accidental discovery of kaolin and pihtunse led Macquer, the superintendent of the establishment, to the production of hard porcelain; but the manufacture of soft porcelain was not entirely abandoned till 1804. This manufactory has produced the most beautiful examples of European porcelain, distinguished by the beauty and brilliancy of its colours, the dark and light blue, yellow, green, and Dubarry, or rose-pink, and the elegance of its paintings, after Watteau and other artists, although the forms till 1785, when classical shapes were introduced, by no means equalled its rivals of Dresden. The high prices and demand for this elegant article of vertu have led to various counterfeits, the doctoring of old specimens, and the fabrication of modern imitations, so that it is as difficult to detect spurious Sèvres porcelain as false coin. Other places, as Chantilly in 1735, Orleans in 1753, Arras in 1782, Tournay in 1750, and Paris in 1773, manufactured soft or hard porcelain; and in 1735, at La Doccia, near Florence, a hard and a hybrid porcelain was manufactured in imitation of oriental, Sèvres, and Capo di Monte, distinguished by its modelled forms. At Venice the manufacture ceased in 1812. At La Nove, near Bassano, in Lombardy, at Turin in the end of the 18th century, and at Capo di Monte, near Naples, a porcelain, finely painted and moulded in high relief with shells and figures, is said to have flourished from 1736 to 1821, an offshoot of which was established at El Buen Retiro, near Madrid, about 1759, but was completely destroyed in 1812; but another fabric was subsequently established near Madrid in 1827. A fabric of hard porcelain flourishes at Vista Alegre, near Oporto.

Although the use of vessels with plumbiferous glazes has been in great part superseded by other wares, yet it is still extensively manufactured in England, France, Germany, Portugal, and in Switzerland, different localities using different processes, as the actual metallic lead in Finisterre, and the galena in other places, as in Sardinia. The manufacture of majolica has in fact never quite disappeared in Europe; into Naples it was introduced at the close of the 18th century, and pieces of a peculiar kind were made; the recent majolica of Venice is thin, with bluish-white enamel and ornaments in *repoussé* work. In Holland, a manufactory, the survivor of the delftware, still remains. Glazed wares of a green colour are made at Smyrna; in India, and at Pegu. The use of stanniferous glazes in the East has been continued till the present day, since an early period: they are still used in Turkey, Asia Minor, and Marocco, with red ornaments on a white ground, and oriental patterns. At Shershel, in Algeria, lamps are made. In Persia, as early as 1146, fayences of deep blue, with white ornaments, and of a golden colour at a later period, have been made. In Arabia, the use of enamelled wares, especially for tiles and other architectural ornaments, dates from the 10th or 11th centuries.

The modern potters, like the ancients, often placed on their ware inscriptions giving the name of the place of manufacture or of the maker. Those on the early French and Italian majolica are initial letters, monograms, dates, and coats of arms. Thus, Savona has the arms of the town; Nevers, N.; Rouen, a fleur-de-lis; B. stands for Bernard Palissy; Höchst has a wheel; Cologne, an anchor; Delft, occasionally a sword; Wedgwood and his successors stamped their names; old Dresden has the monogram A. R., King Augustus, K. P. M., "the Royal Porcelain Manufactory," and crossed swords; Venice, the imperial arms; Fürstenburg, an F.; Frankenthal, the lion and crown; Nymphenburg, the arms of Bavaria; Ludwigsburg, a ducal crown and C. C.; Berlin, a globe and cross; Fulda, F. crowned; St. Petersburg, a K. crowned; the Hague, a stork; Copenhagen, waves; Nyon, trouts; Chelsea, anchors; Derby, a crowned D; Plymouth, the astrological sign for Jupiter; Worcester, W. and other marks; Swansea, a trident. Sèvres has several marks,—a sun under Louis XIV., a crowned eagle under Napoleon, a comet; the other French potteries have monograms and marks. The Chinese marks have the name of the maker, or date when made, generally in red or blue, in a square label in the seal or court characters, imitating the impression of the seals or stamps they affix to their documents and books.

The application of the fine arts to the embellishment of porcelain, and the refinements of luxury, have vastly increased the value of modern porcelain. For a long time hard porcelain was the monopoly of princes, and the expense of producing specimens with charming colours and elegant designs was very great; but the desire of possessing beautiful and rare specimens by the rich has greatly increased their value: for example, the majolica salt-cellars have realised at public sales from 10 guineas to 64*l.*; the Gubbio plates from 11*l.* to 21*l.*; those of the artist Xanto 80*l.*, and vases of larger size 220*l.*; a Palissy candlestick, 84*l.* The ware of La Doccia has augmented its price 2000 per cent., and a small cup of this ware is worth from 30*l.* to 40*l.* Chelsea vases of any size, painted with religious or historical subjects, obtain from 100*l.* to 150*l.*, and small cups of this ware 25*l.* to 30*l.* Nor has the reputation of Chinese crackle declined, and even mandarins might pause at the prices given; 60*l.* and 70*l.* being paid for sea-green or turquoise blue vases. Green crackle has found amateurs to purchase at 131*l.*; and a few flat jars, surmounted by kelins, or mystical stags, 235 guineas. Last, though not least, two jars have been the subject of a suit in Chancery. Under such circumstances, the acquisition of instructive collections transcends the power of princes or the prudence of governments.

(Brongniart, *Traité des Arts Céramiques*, 8vo, Paris, 1844; Birch, *History of Ancient Pottery*, 8vo, Lond., 1858; Marryat, *History of Pottery and Porcelain*, 8vo, Lond., 1857.)

POTTERY AND PORCELAIN, MANUFACTURE OF. The object of the present article is to add a few further observations to the manufacturing details given under EARTHENWARE; and to apply those details to the two kinds of ware which form the extremes of the series, namely, fine or *porcelain*, and coarse or *pottery*: *earthenware* occupying a medium position between the two.

In the beginning of the last century, it was ascertained by experiment that the earths alone are infusible, but that when silex is combined with aluminous earth, and subjected to a strong fire, it unites chemically with the clay, as an acid unites with a base; and that when a third earth, having alkaline properties, as lime, magnesia, or barytes, is added, a more complete change is effected, and a vitrified body is produced, resembling in density and fracture many natural gems. When the earthy materials are free from metallic matter, a perfect *porcelain* is thus produced. It was found that seven parts of silex, six parts of aluminous earth, and two parts of an alkaline earth, would produce such a body. On this principle the Germans and French founded their porcelain manufactures. In England the enterprising spirit of Wedgwood wrought a complete revolution in the art; and by bold experiments, guided by his knowledge of mineralogy and chemistry, he laid the sure foundation for all those improvements which have raised the fictile manufactures of this country to so high a level.

The materials are reduced to the consistence of cream, in which state they are called *slips* (slops); this fluidity is necessary to ensure the perfect mixture of all the ingredients, and their mutual chemical action in the fire. The basis of the composition is a clay from the plastic-clay formation in Devonshire or Dorsetshire, to which is added ground flint, which gives whiteness and solidity to the goods. For the better kinds, a portion of China-clay, or decomposed felspar from Cornwall, is added, together with a small quantity of ground white granite. The processes are conducted as described in EARTHENWARE, until a smooth and homogeneous mass of plastic clay is produced.

It may be well here to give the proportions of ingredients for various kinds of ware or bodies, derived from the actual practice in Staffordshire:—

Cream-colour or *Printed Ware.*—

Dorset clay	56	or	60	or	66
China clay	27		18		17
Flint	14		20		17
Cornish granite	3		2		

Drab-coloured Ware is made of the fine gray marl found between the coal strata, which burns to a cane-colour in the oven; or a white body, as above, is stained with oxide of nickel, which gives it a greenish drab tint; or with oxide of manganese.

Drab body.—

Cane marl	32	or	—	or	56	or	26
Dorset clay	22		43		20		46
Cornish granite	45		50		24		25
Oxide of nickel	1		7		—		—
Manganese	—		—		—		3

The granite in the above bodies gives great density and a very close flinty fracture.

Brown or Chocolate bodies are made with a basis of the red ochreous clay, obtained from the red-marl formation above the coal strata. A great variety of tints may be obtained by judicious combinations of oxides of iron, as umber, calcined copperas, bole, &c.

Brown.—

Red clay	83	or	60
Dorset clay	13		30
Flint	2		10
Manganese	2		

Egyptian Black, for tea-pots, ink-stands, &c., is made in the same way, but with a larger portion of the oxides of iron and manganese.

Black.—

Red clay	45	or	34
Dorset clay	36		42
Manganese	13		12
Protoxide of iron	6		12

Blue bodies are produced by the mixture of a small quantity of oxide of cobalt with a fine white body; when made of vitrescent materials, so as to give a gem-like surface without glazing, it is termed *jasper*. This beautiful article is well known by the splendid productions of Mr. Wedgwood.

Jasper bodies.—

Sulphate of barytes	48	or	Carbonate of barytes	34
China clay	16		China clay	15
Dorset clay	24		Dorset clay	15
Flint	10		Cornish granite	33
Gypsum	2		White lead	3

These mixtures give a fine white body for ornaments, which may be stained blue by the addition of one per cent. or less of oxide of cobalt, according to the strength of tint required; or a green jasper may be produced by staining with protoxide of chrome.

Turquoise bodies.—A body called turquoise has been manufactured to a great extent. It is nothing more than a good white body, stained with a mixture of oxide of cobalt, combined with a large proportion of oxide of zinc; when glazed, it has the peculiar milky tint of the gem after which it has been named.

In this manner, by a proper combination of metallic oxides, either as existing in earthy materials, or prepared from their metals, an infinite variety of coloured bodies may be produced. They are usually prepared on slip-kilns of small dimensions, the bottoms of which are covered with a layer of plaster of paris, if used for the finer colours.

Referring to EARTHENWARE for an account of the manner of fashioning circular vessels on the potter's or *throwing* wheel; turning them to the proper thickness, and working mouldings, &c.; fixing on handles and spouts; and making the peculiar variety called *dipped ware*: we shall add a little to the details there given concerning *ornamented* ware and *flat* ware.

Thrown and turned goods are sometimes ornamented with figures in relief, which are made out of flat moulds by children, and fixed upon the ware by workmen, who, having carefully adjusted each figure to its place, run a little water under it with a camel-hair pencil, which unites it to the surface. Goods of an oval or angular shape, which cannot be turned, are made by pressing clay into plaster moulds, which give the outside form to the vessels. For this purpose the mould is made in two parts, and each is separately filled by laying in a cake of clay that has been beaten out to the proper thickness on a wet plaster-block; it is pressed into the mould by repeated blows from a ball of wet sponge, then squeezed into all the angular parts with the fingers, and smoothed with sponge, wet leather, and horn. When both sides of the moulds are thus lined with clay, they are joined together; and the workman lays a roll of clay along the inside of the joining, which he works down until the whole is smooth and solid. The mould is then carried into a stove-room; and when it has absorbed the moisture, so as to release the clay, the work is carefully taken out, and the empty mould returned to the stove previous to being filled again. The seam which remains on the outside of the vessel is removed by scraping and burnishing with wet horn; the handles and other appendages are then attached. This branch of the trade is called *hollow-ware pressing* or *squeezing*. *Flat-ware pressing* is performed by giving the shape to the goods by moulds which fit the *inside* of the vessel; plates, dishes, saucers, cups, and hand-basins are made on this principle by the English potter, with a dexterity which must be seen to be understood, and which excites the surprise of foreigners more than any other branch. The workman stands at a bench provided with a whirling-table similar to the thrower's, but which has its motion given by a horizontal pulley or jigger, turned by his young assistant. Close to his left hand is a *batting-block* of wet plaster, and the mass of well-beaten clay from which he is working; immediately behind him is the stove-room, in which the moulds are ranged on shelves. All being ready, the plate-maker cuts his clay into lengths with a wire, and tears off a piece which he *bats out thin* upon his block by a stroke or two of his *batter*, or plaster-mallet, and polishes the surface by pressing the side of a long smooth knife across it. During this process, which occupies but a few seconds, the boy has brought a mould, placed it upon the whirler, and taken his place at the handle of the jigger. The man places the clay upon the mould, and as it whirls, presses it down close with his hand; a profile, or earthenware tool which gives the form to the bottom of the plate, is pressed upon it as it revolves, the superfluous clay being cut off by a wire; the boy instantly catches hold of the mould thus covered with a coating of clay, runs with it to the stove, places it on a shelf to dry, and returns with an empty mould; by which time his master has his clay prepared for another plate. When sufficiently hardened, the bottom of the plate is polished; and when taken off the mould, the edges are smoothed and polished with moist leather. Cups, saucers, and hand-basins are now made by this process, instead of being thrown and turned as formerly. By this means they are supplied at a cheaper rate; one man and a boy being able to manufacture the articles which by the old mode requires the work of three men and three females.

Casting is resorted to when a mould is so intricate as to be difficult for the workmen to fill by pressing. Slip clay is poured into the mould, which rapidly absorbs the water, and a coating of clay is deposited upon the inside; the remaining fluid is then poured out or drawn with a syringe, and a thicker mixture is put in, and left rather longer than the first before it is withdrawn. The mould is then put into a stove to dry. Goods thus made are very light.

When completed by the workman, the goods are placed on boards to dry, before going to the biscuit-oven, in which they receive the first fire. The details of the process are described in the article already cited; and the ware, now in the state of *biscuit*, is ready for the blue-printer or for the artist, according to its quality and intended appearance.

In the old days, before the expeditious and cheapening process of electrotyping was known, a set of engraved plates for a table-service commonly cost 130*l.* or 150*l.*; and would, with proper care, print 2000 dozen services before it wanted recutting. The ink used in printing is made of linseed-oil, boiled with litharge, rosin, balsam of sulphur, or Barbadoes tar; almost every printer has his favourite recipe for making this tenacious oil, which is the vehicle of the colour to be used. *Blue* colour is made of oxide of cobalt, mingled with flint or carbonate of lime so as to dilute it to the proper tint. *Lilac*, of smalts 2 parts, manganese 1. *Brown*, zaffre 2, litharge 2, antimony 1, manganese 1. *Red-brown*, manganese 12, litharge 2, flint 2, glass 1, borax 1. *Orange*, litharge 6, antimony 4, oxide of tin 1, oxide of iron 2. *Pink*, subchromate of tin and carbonate of lime, equal parts. *Green*, oxide of chromium, the tints varied with cobalt or tin. *Black*, red-lead 60, antimony 25, manganese 15, fritted together; then add oxide of cobalt 40, oxide of tin 5.

Some patterns are executed on biscuit by painters, who lay on the colours in gum-water, in which case the firing in the muffle is not required; but the choice of colours in this kind of painting is rather limited, as the heat of the glazing-oven and the chemical action of the materials of the glaze would be destructive to many colours which are used by the enameller upon the glaze. For a description of the modes of printing and glazing, see EARTHENWARE. The following glazes are excellent, and have been successfully used in the Staffordshire potteries; they must be ground very fine at the mill. *Cream-colour glaze.*—White-lead 66, Cornish granite 22, flint 12. *Printed-ware glaze.*—White-lead 45, Cornish granite 28, flint 13, flint-glass 14. In these forms, the ingredients are simply ground together, and are therefore called raw glazes, in distinction from such as have a portion of the materials first united by calcination into a frit, or incipient glass; by this practice, a more complete combination is effected, a thinner coating of glaze will suffice, and the ware in consequence is less liable to craze with change of temperature. *Fritted glaze.*—Cornish granite 30, flint 16, red-lead 25, soda 12, borax 17; mix and calcine in the easiest part of the gloss-oven, in saggers lined with flint; then take of the frit 26, Cornish granite 15, flint-glass 10, flint 9, white-lead 40; grind the whole with a little oxide of cobalt, to increase the whiteness. *Drab-ware glaze.*—Litharge 56, Cornish granite 20, flint 24. *Blue glaze.*—Flint 40, borax 24, red-lead 16, Cornish granite 7, soda 5, oxide of tin 5, oxide of cobalt 5; calcine, then grind with the addition of a little pearl-ash. *Green glaze.*—Dissolve six pounds of sulphate of copper, and precipitate it with a solution of borax; to which add 10 quarts of white glaze. *Yellow glaze.*—Colour a white glaze with king's yellow, to the depth of tint desired; or chromate of lead. *Black glaze.*—Red-lead 74, flint 14, manganese 10, protoxide of iron 2.

We proceed to point out the chief differences between *earthenware* and *porcelain*.

Porcelain is a finer species of ware, in which the ingredients are so selected that they act chemically upon each other, and are brought to a state of vitrification. The fracture has a dense or greasy surface, like that of a flint stone, and is not liable to be acted upon by acids. When the porcelain is coloured by metallic matter, it is called *stone-ware;* jasper and some drab-ware are of this description; but when it is perfectly free from colouring matter, and is translucent, it is called *China:* of which there are two species, *hard* and *soft*. It is necessary to bear in mind, however, to prevent confusion, that many writers treat *porcelain* and *china* as convertible terms, applying the former name as well as the latter to translucent ware only.

Hard china is made of silex, generally a fine sea-sand, kaolin or china-clay, and felspar; sometimes the felspar is omitted, and a small quantity of selenite, or carbonate of barytes, or strontian, is used in its place.

Hard China body is made of kaolin 70, felspar 14, sand 12, selenite 4. The mixture is sometimes made in lime-water, and must be ground very fine at a mill. When the paste is moulded into the desired forms, it is fired in the biscuit-oven at a moderate heat; when taken out, it is very bibulous, and opaque. In this state it is dipped in the glaze, which is felspar, ground fine, with the addition of a little alkali. Some prefer a mixture of felspar and broken china ground together. It is then submitted to a second fire of great intensity, which not only melts the glaze on the surface, but vitrifies the entire mass, which thus unites with the softer matter on the surface so completely, that the glaze does not form a coating of glass upon the body, but appears like the surface of a stone polished by a lapidary. This homogeneity prevents any crazing; but the process is one of much hazard, for if the fire is prolonged beyond the critical moment when the vitrification is effected, and the surface has become bright, the goods will melt, and sink in the saggers. Oriental, French, and German china are made on this principle; but the English have followed the safer practice which we shall next describe, and which the French manufacturers, aware of its advantages, now adopt. *Soft or Tender China* is made by firing the biscuit to its full vitrescence in the first oven, the shape of the articles being preserved, during their vitrescence, by being imbedded in flint-powder, &c.; and then glazing in the second oven at a lower degree of heat, so as not to endanger the melting of the goods. The union between the body and the glaze is however more complete than in earthenware, the glazing-fire being much more intense. Bones calcined and ground are largely used in the manufacture of English china, combined with aluminous and silicious earths in such proportions that they will vitrify together. This effect is promoted by the phosphoric acid of the bones, which at a high heat diffuses itself through all the materials, and unites them into a translucent enamel, less apt to sink and lose its form than the hard porcelain; it therefore may be made in larger ovens, and with less risk of loss to the potter. *English China body* consists of bone 46, china clay 31, Cornish granite 23. For large pieces, such as dishes, &c., a little Dorset clay is added, to give more ductility in working and more stability in the fire; but when great purity of whiteness and transparency are wanted, a higher degree of vitrescence is obtained by fritting silex and bone together as the basis of the body. *Fritted China body* comprises bone 55, Lynn sand 27, potash 2, calcined together; then ground fine, with China clay 18. *Glaze for China* is harder than for earthenware. The following is excellent:—Cornish granite 25, soda 6, borax 3, nitre 1; mix, and frit in gloss-oven; then take frit 26, Cornish granite 26, white-lead 31, flint 7, carbonate of lime 7, oxide of tin 3. The whiteness is increased by the addition of a little oxide of cobalt. Another China glaze consists of felspar 38, Lynn sand 24, carbonate of lime 11, borax 27: to be fritted; then take frit 60, Cornish granite 20, white-lead 20.

The application of the glaze and mode of firing are the same as already described.

The decoration of china by enamel colours and gold affords employment to a great number of persons, some of whom attain great excellence in their art. The colours used are all prepared from metallic oxides, which are ground with fluxes, or fusible glasses, of various degrees of softness, suited to the peculiar colours with which they are used. The flux of most general application is made of red-lead 6, borax 4, flint 2. When painted, the goods are placed in the enamel-kiln, where the fluxed colours melt, and fasten to the glazed surface. The judicious management of these mixtures requires much study, and is still susceptible of improvement by the aid of chemical science. *Blues* are made from cobalt, varied by the addition of the oxides of zinc or tin. Phosphoric acid gives it a rich purple tint; alumina also varies its hue. *Green* is from oxide of copper, melted with a soft flux, and ground; its tints are varied by adding blue or yellow or white enamel. Fine greens, which bear a fire that destroys a copper-green, are made from protoxide of chrome, varied with the addition of cobalt, lead, tin, or alumina. *Red* consists of nitrate of iron, dichromate of lead, or muriate of manganese. *Pink*, of subchromate of tin. *Rose-colour*, of gold and tin (precipitate of cassius) with a little silver. *Brown*, of chromate of iron or antimony, lead, and manganese. *Orange*, of antimony, tin, and iron. *Yellow*, of antimony, tin, and lead; also chromate of lead. *Black*, of oxide of platinum or iron, cobalt, nickel, and antimony. *White*, of arsenic and tin. An infinite variety of tints may be obtained by a skilful combination of the above with suitable fluxes, the description of which in detail would exceed our limits. Few potters prepare their own colours; they are supplied by persons who devote themselves to that art.

Gold is applied to china in the state of amalgam ground fine in turpentine with a metallic flux. Thus, gold oxidised by being thrown in a melted state into aquafortis, 1 ounce; quicksilver 14 pennyweights, oxide of bismuth 1 pennyweight, chloride of silver 2 pennyweights. In the enamel-kiln, the bismuth and silver melt, and fix the gold to the china, without dissolving it so as to prevent its being burnished.

There has been some dispute (into which it is unnecessary to enter) as to the invention of *parian*, the beautiful biscuit-ware adopted for statuettes. The substance itself came into use about the year 1842, and is difficult to manufacture; the articles are moulded in many pieces, and shrink much during several successive firings.

Pottery.—This name is often given to the coarser kinds of red, yellow, and brown ware, such as that of which large vessels are made; but the word, like *porcelain*, is used in a very indeterminate way. Be the name what it may, however, the substance itself has become commercially of much importance. Lambeth is the head-quarters of this manufacture. What is called *Lambeth stoneware* is a vitrified body, having its surface coated with a glaze made at a very high heat by throwing salt into a hot oven; or with a glaze of silicate of soda. According to a paper read by Mr. Goddard, before the Society of Arts, in 1860, there were in Lambeth, about the year 1820, six or seven potters, having sixteen small kilns of 8 feet diameter, making about 20*l.* worth per kiln-full of blacking-bottles, ginger-beer bottles, pickle-jars, and articles of a like kind; and for some years afterwards the trade did not materially change its character. At a later date, however, when sanitary measures began to be adopted in the metropolis and other towns, a demand for stoneware drain-pipes gave a new impetus to the Lambeth potters, who have ever since made rapid advances in the scale of their manufactures. Casting in moulds and turning in the lathe are processes now much more adopted than formerly in the production of this kind of ware; as a consequence, the quality and finish of the articles are greatly improved. The Lambeth potters used to content themselves with any kind of clay that came to hand; but now the higher kind of ware demands the clays of Devon and Dorset, and a peculiar variety found near Fareham. Vessels are now made of Lambeth stoneware capable of containing 800 gallons; they are formed of layer upon layer of clay, successively and carefully applied, and each is hardened before the next is added. Filters for domestic use now constitute a large and important department of Lambeth manufactures. Drain and other pipes, condensers and worms for distilling, pumps, jugs, ladles, funnels, pans, baths, jars, druggists' pots, tobacco jars, telegraph-insulators—these are among the large number of articles made of Lambeth stoneware. There are now in this district seventy kilns, with an average capacity of 50*l.* worth of ware per kiln. One firm alone, that of Messrs. Doulton, consume about 8000 tons of coal and 8000 tons of clay annually; for it appears that, taking one kind with another, the stoneware requires about as much coal to bake it as clay to make it.

Of the commonest kinds of pottery, such as flower-pots, &c., nothing need be said; the cheapest clay and the quickest work suffice for their production.

POTTING OF PLANTS. When plants are placed to grow in a small earthen vessel, like a garden pot, their condition is very different from that to which they are naturally exposed. The roots have not liberty to extend themselves as they choose, and they are either obliged to grow back upon themselves or round the vessel in which they are confined; they are likewise exposed to great varieties of temperature and depend on an uncertain supply of moisture. It is therefore the object of the careful gardener to obviate as much as possible these evils, and at the same time to secure the advantages derived from the operation itself. These advantages consist mainly in the facility with which it enables the gardener to change the arrangement and position of his plants; it also, by cramping the roots, diminishes the tendency to form leaves, and increases the disposition to flower. It secures a constant and effective drainage from the roots, and renders it more easy to expose them to a favourable amount of bottom heat. For the raising and nourishment of young seedlings it is also an advantageous process. Exhaustion of the soil is one of the inconveniences which result from this system. In order to remedy it liquid manure should be applied; or the plants placed in *pan-feeders*, shallow earthen vessels containing manure, to which the roots have access through holes in the bottom of the pot. It is however *to shifting* more particularly that recourse should be had for renovating the soil; and this, if skilfully performed without injuring the plant, is most successful. It is not alone for the purpose of improving the soil that shifting is desirable; the roots if allowed to remain long in a confined space form a hard knotted mass, which is very unfavourable to the retention of moisture and the growth of the plant. All the earth therefore which clings to the roots should be carefully separated before the plant is placed in the fresh soil. The roots of a plant are always found to be in contact with the sides of the pot, and this being generally composed of a highly absorbent substance, is subject to great variations of temperature. The practice of plunging greenhouse plants into the earth during the summer to obviate this is very undesirable, as when they are again taken up the roots are generally found to have taken advantage of the earth around them and to have fastened themselves in it. The drainage of potted plants is of great importance, and in all cases a quantity of broken pieces of tiles and earthenware should be placed at the bottom of the pots to prevent the stagnation of water about the roots. To be managed perfectly a young plant should be placed in as small a pot as it will grow in, and gradually and successively transferred to large pots as it advances. Dr. Lindley ('Theory of Horticulture') says, "It is by paying constant attention to the shifting of the growing plant, by the employment of a very rich stimulating soil, and by a thorough knowledge of the kind of atmosphere which suits them best, that have been obtained those magnificent pelargoniums, cockscombs, and balsams, &c., that have so often and so justly excited the admiration of even the most experienced gardeners."

POULTRY, from the French *poulet*. The term includes all the domesticated birds reared for the table; fowls, turkeys, geese, ducks, and Guinea fowls.

Fowls.—"The strong and ambulatorial feet of the gallinaceous birds adapted to the region where they chiefly resort for their food and the purposes of incubation; their toes and nails peculiarly formed for scratching up the grains and seeds which constitute the main part of their subsistence; their short wings and the weakness of their pectoral muscles, which cause the heaviness of their flight, a deficiency which is counterbalanced by the strength of those muscles of the thighs and legs that contribute to their powers of running; their gregarious, and, generally speaking, polygamous habits: the ease with which they are domesticated; their wholesome flesh; together with many striking peculiarities in their anatomy, serve equally to distinguish them." (Vigors, 'Linnean Transactions,' p. 402.)

Some foreign varieties have not even the rudiment of a tail, while others are distinguished by it. The game cock, which is probably a native of India, though for many centuries established in England, has an unusual length of spur, his natural weapon of combat. The flesh of this variety is delicately white and of the finest flavour, the plumage brilliant, and the form symmetrical; but from their pugnacious temper there is great difficulty in rearing even those of the same brood; and for companionship with the general inmates of the fowl-yard they are very exceptionable for the same cause. So pugnacious however are the males of almost every variety, that they will spur even before their spurs are grown. For the natural history and peculiarities of the various varieties, we refer to PHASIANIDÆ, *Gallus*, in NAT. HIST. DIV.: we shall merely notice in this place the kinds suited to the purposes of the farmer.

The best breed of the gallinaceous fowls is the produce of the Dorking (Surrey) cock and the common dunghill fowl. This cross is larger and plumper, and more hardy than the pure Dorking, without losing delicacy of flavour or whiteness of flesh.

The characteristics of the pure Dorking are, that it is white-feathered, short-legged, large-bodied, and a fair layer. The peculiarity of this established variety, which has frequently five claws perfectly articulated (with sometimes a sixth springing laterally from the fifth, but always imperfect), is well known. The crossing with the Sussex fowl has however greatly diminished the monstrosity in the Surrey pentadactylus variety. But though the true Dorking, which is white, is much esteemed, that colour is rare, and prized for the ornament of the poultry-yard: speckled colours are most generally seen with the higgler.

The Poland breed, which is black-feathered, with white topknots, lays well, and is highly desirable where the production of eggs for the table is the principal object; but they seldom sit, though they cannot be considered long-legged.

The Chittagong, or Malay, which is a very large Indian variety, is generally long-legged, with yellow body and coarse yellow flesh. Fanciers used to like them for their fine appearance and their large eggs; but as their long legs incapacitate them from steady sitting, they are not general favourites. One of our practical acquaintances recommends the male produce of the Poland and Chittagong as a good cross with the common dunghill hen, as their progeny will sit.

The Cochin China fowl, brown or buff coloured, is a large shorter-legged bird, a constant layer, and brought largely into use of late years: its eggs are small. The Spanish or black fowl is also a constant layer of large eggs. The following on the characteristics of poultry is from the pen of a writer in a journal which has now ceased to exist, the 'Poultry Chronicle:'—

1. *Game Fowls.*—Elegant and compact in appearance, hardy in constitution, excellent caterers for themselves, good layers of delicious eggs, excellent mothers and rearers of progeny, chickens unsurpassed in flavour when dressed. The sole drawback to this prince of breeds is their disposition to fight; but I cannot say that this amounts to much, as during the time I kept them, I lost but four or five chickens from this cause.

2. *Spanish.*—Noble birds, abundant layers of very large eggs, may be kept in confined spaces more readily than other breeds, no mothers, but the chickens hardy, only wanting extra attention at about a month to six weeks old when feathering, good table-bird—should be well kept.

3. *Dorking.*—Genuine old English fowl, somewhat delicate in constitution, and seems to thrive most on warm and dry soils; eggs large and well-flavoured, but not abundant, fair mothers, chickens not so easy to rear as other breeds, splendid table-fowl where a large plump bird is preferred, wants liberal keep and warm housing.

4. *Gold and Silver Pencilled Hamburgs.*—Extremely elegant in appearance, forage well for their living, but require more feeding than the game fowl lay abundantly, but small eggs; never incubate, or

but very rarely; chickens somewhat difficult to rear, unless in very favoured spots; nice birds for eating, but small; must have a good range to keep them in health.

5. *Spangled Hamburgs.*—Very handsome, abundant layers, chickens tolerably hardy, and a very good bird for the table; their incubating qualities are seldom manifested; require a good run.

6. *Polish.*—Good layers, very elegant in form, rare incubators, chickens very delicate at first, warm housing indispensable.

7. *Cochin.*—Varied plumage, hardy, excellent eggs and more abundant than any other breed, good mothers, chickens strong, and grow rapidly under good feeding; good for table at four months old, but not after; require very liberal feeding; feathers valuable.

Those who intend to rear fowls or any kind of poultry on a large scale, should have a distinct yard, perfectly sheltered, and with a warm aspect, well fenced, secure from thieves and vermin, and sufficiently inclined to be always dry, and supplied with sand or ashes for the cocks and hens to roll in, an operation necessary to disengage their feathers from vermin: running water should be especially provided; for the want of water, of which all poultry are fond, produces constipation of the bowels and inflammatory diseases; and for geese and ducks, bathing is an indispensable luxury. A contiguous field is also necessary for free exercise, as well as for the supply of grubs and grass to the geese. The fowl-house should be dry, well-roofed, and fronting the east or south, and, if practicable, at the back of a stove or stables; warmth being conducive to health and laying, though extreme heat has the contrary effect. It should be furnished with two small lattice windows, that can be opened or shut at pleasure, at opposite ends, for ventilation, which is frequently necessary; and the perches should be so arranged, that one row of roosting fowls should not be directly above another.

M. Parmentier has shown ('Dictionnaire d'Agriculture') by what arrangement a house twenty feet long and twelve feet wide may be made to accommodate 150 hens at roost. The plan is this:—the first roosting-perch (rounded a little at the upper angles only, for gallinaceous fowls cannot keep a firm hold on perfectly cylindrical supporters) should be placed lengthways, and rest on tressels in each end wall, six feet from the front wall, and at a convenient height, which must depend on the elevation of the house from the floor, which should be formed of some well consolidated material that can be easily swept. Another perch should be fixed ladder-ways (*en échelon*) above this, but ten inches nearer to the back wall, and so on, until there are four of these perches, like the steps of a ladder when properly inclined, but with a sufficient distance between the wall and the upper one to allow the poultry-maid to stand conveniently upon when she has occasion to examine the nests, which it is her duty to do every day at least once, and in the forenoon. The highest of these she can reach by standing on a stool or step-ladder. By this contrivance the hens, when desirous of reaching the nests, have no occasion to fly, but merely to pass from one stick to another. If the size and form of the house permit, a similar construction may be made on the opposite side, care being taken to leave an open space in the middle of the room, and a sufficiently wide passage for the attendant to pass along the walls. It is not at all required to have as many nests as hens, because they have not all occasion to occupy them at the same time; and besides, they are so far from having a repugnance to lay in a common receptacle, that the sight of an egg stimulates them to lay. It is however true that the most secluded and darkest nests are those which the hens prefer.

The nests, if built into the wall, are in tiers from the bottom to the top, the lowest being about three feet from the ground, and a foot square. If the laying-chambers consist of wooden boxes, they are usually furnished with a ledge, which is very convenient for the hens when rising.

But the best receptacles for the eggs are those of basket-work, as they are cool in summer, and can easily be removed and washed. They ought to be fastened not directly to the wall, as is generally the case, but to boards fixed in it by hooks, well clinched, and with a little roof to cover the rows of baskets. They will thus be isolated, to the great satisfaction of the hen, which delights in the absence of all disturbing influences when laying. All the ranges of nests should be placed cheque-wise, in order that the inmates, when coming out, may not startle those immediately under: those designed for hatching should be near the ground (where instinct teaches the hen to choose her seat), and so arranged that the hens can easily enter them without disturbing the eggs.

Wheaten or rye straw is the most approved material for the bedding, being cooler than hay: the hens are sometimes so tortured by lice as to forsake their nests altogether, in an agony of restlessness. A Dorking housewife has assured us that she once lost an entire clutch, from having, as she believes, given a bed of hay-seeds to her sitting hen. The chicks were all glued to the shells, and thus destroyed, owing, as she thinks, to the high temperature occasioned by the fermenting seeds.

For all purposes two cocks in a good run are considered in the poultry counties contiguous to London as sufficient for twelve or fourteen hens, but in France they allow twenty mistresses to each cock, which no doubt is on account of the higher temperature there. In a confined yard, five hens are sufficient for one cock in our cold country, and a double set will not answer in very limited space. When there are two or more cocks, care should be taken not to have them of equal age or size, for in this case they are always jealous and quarrelsome; if one is decidedly ascendant, the other will never presume to dispute with him. It will be judicious also to avoid the introduction or changing of cocks in the breeding season, for the hens require constant intercourse with them, and several days frequently elapse before they become familiarised with a stranger. The best way is to bring in the new cock in the summer, either as a chick, or late in the year in the moulting season, when he will not take too much notice of the hens. As a general rule it would be well to have one a yearling, and the other a year older. In the third year, the cock, who then becomes lazy and excessively jealous, should be killed.

In order to have the earliest chickens, hens should be induced to sit in October, which they may do if they have moulted early. By attention in this particular, chickens can be brought to the market at Christmas. But the object should be in general to set the eggs as soon as possible after Christmas, in order to have chickens with the forced asparagus in March, when they are worth in London from 7*s.* to 10*s.* a couple.

In selecting eggs for hatching, care should be taken that they are not at the utmost more than a month old, but their condition for hatching will greatly depend upon the temperature of the weather: vitality continues longest when the air is cool.

It has been asserted that the future sex of the bird is indicated by the shape of the egg; the round producing the female, and the oblong the male. But this is contradicted, and, we believe, with sufficient reason; and it is impossible not only to foretell the sex, but even to ascertain whether the egg be fecundated. This however is certain, that if the air-bag (at the obtuse end), which has been mistaken for the germ, and the purpose of which is to oxygenate the blood of the chick, be perforated even in the least conceivable degree, the generating power is lost altogether. Those eggs only which have been fecundated by the male are possessed of the vital principle. The number of eggs for a hen should not exceed sixteen, as she cannot impart the necessary warmth to more. It is by no means uncommon with experienced breeders to place two hens on the same day on their respective eggs, and then on the twenty-first day, when the broods are out, to give the maternal charge of both to one of the hens, removing the other to another set of eggs, which, if she be a steady sitter, she will hatch as in the first instance. This however must be deemed a cruelty, though some hens would instinctively continue to sit until death. They would however become so attenuated by constant sitting, as to lose the power of communicating to the eggs the necessary degree of warmth. The practice of the Surrey breeders is to feed the hen on oats while sitting, as less stimulating than barley, which they give to the laying hens on account of this very quality.

Some fanciers use artificial mothers, which effect the purpose of imparting the necessary heat to the young chicks after birth, when there is no natural mother nor a trained capon to brood them. These artificial mothers—as used by Mr. Moubray, and described by him—are boxes lined throughout with wool. He recommends that a curtain of flannel should be suspended over the opening of the box for the exclusion of cold air.

Mr. Young states that "five broods may at once be cherished under an artificial mother. This mother may be framed of a board ten inches broad and fifteen inches long, resting on two legs in front, two inches in height, and on two props behind, two inches also in height. The board must be perforated with many small gimlet-holes, for the escape of the heated air, and lined with lamb's skin dressed with the wool on, and the woolly side is to come in contact with the chickens. Over three of these mothers a wicker basket is to be placed for the protection of the chickens, four feet long, two feet broad, and fourteen inches high, with a lid open, a wooden sliding bottom to draw out for cleaning, and a long narrow trough along the front, resting on two very low stools, for holding their food. Perches are to be fixed in the basket for the more advanced to roost on. A flannel curtain is to be placed in front, and at both ends of the mothers, for the chickens to run under, from which they soon learn to push outwards and inwards. These mothers, with the wicker baskets over them, are to be placed against a hot wall, at the back of the kitchen fire, or in any other warm situation where the heat shall not exceed 80 degrees of Fahrenheit.

"When the chickens are a week old, they are to be carried with the mother to a grass-plat for feeding, and kept warm by a tin tube filled with hot water, which will continue sufficiently warm for about three hours, when the hot water is to be renewed. Towards the evening the mothers are to be again placed against the hot wall."

The artificial mother, however, is only a mechanical house for chicks already hatched; but the process of bringing the embryo of organised life in the egg through all the stages of the vital principle until it becomes matured, by means of heated ovens, has been long and successfully practised in Egypt.

These ovens, which are constructed with bricks, are about nine feet high, with galleries extending through the whole length, and containing chambers into which a man can creep through a very contracted orifice for the purpose of depositing the eggs, which are laid, to the amount of several thousands, on mats or beds of flax over the brick floors. The heat is conveyed through fire-places, and the material of the slow fires, which are most effective, is the dung of cows or camels combined with straw. The fires are kept up for as many days (according to the temperature of the weather) as are sufficient to impart such a degree of heat as will continue to the expiration of the twenty-one days required for the hatching of chickens, care being taken to confine the warmth by closing up all the orifices communicating with the external air. One hundred millions of chickens are said to be thus annually produced in Egypt. For the details and statistics on this interesting subject, see the Domestic Habits of Birds, 'Library of Entertaining Knowledge,' p. 138.

M. Réaumur made various experiments in hatching with fermenting dung in hotbeds, but unsuccessfully; life was developed, but never matured; the chicks were in some cases even feathered, but long before the full time they lost vitality. He succeeded at length, "after trials enough to wear out the most enduring patience," with an oven free from the influence of the vapour exhaled from the dung, which in the previous experiments had been destructive of the embryo. He afterwards succeeded to a great degree by using a box or shelves over an oven, with due regard to uniformity of temperature. Several of the eggs in this latter case were hatched on the twentieth day, by which the usual course of nature was anticipated by one day. But though artificial hatching has long been practised with success in Egypt, it has not been found worth the expense and trouble in France, from the variableness of temperature there compared with that in the Delta, where, in the autumnal season, when the mamals (hatching-ovens) are used, it is remarkably steady and extremely warm.

As the attempt to pursue the Oriental system has failed in France, there is no probability of its succeeding in the climate of Great Britain; but it by no means follows that success may not attend such management as will obviate the obstructions which arise from irregularities of temperature. The object was indeed attained some years ago by means of the application of the Eccaleobion (from 'Εκκαλέω, "I call forth," and Βιος, "life") machinery exhibited in London by Mr. Bucknell, the inventor and proprietor. According to Mr. Bucknell, his eccaleobion possessed a perfect and absolute command over temperature from 300 degrees of Fahrenheit to that of cold water; so that any substance submitted to its influence would be uniformly acted upon over its whole surface at any required intermediate degree within the above range, and such heat maintained unaltered, without trouble or difficulty, for any length of time: and "by means of this absolute and complete command over the temperature obtained by this machine, the impregnated egg of any bird, not stale, placed within its influence at the proper degree of warmth, is, at the expiration of its natural time, elicited into life, without the possibility of failure, which is sometimes the case with eggs subjected to the caprice of their natural parent."

That chickens were thus hatched in considerable numbers is unquestionable, many thousands having been brought into existence by this single eccaleobion machine; nor was any difficulty found in the subsequent rearing of those chickens when proper yards and suitable temperature were provided, more than in the natural way; indeed in some respects less so, as the losses sustained in poultry by the sudden changes of the weather, and the influence of dampness in particular, and accidents from various causes, are very considerable. But probably, from not proving sufficiently economical for commercial purposes, the machine does not appear to have come into use.

The eccaleobion machine, capable of containing 2000 eggs, resembles an oblong box, nine feet in length, three feet in breadth, and the same in height. It has no connection with the walls, against which it is placed on the table on which it stands; its regulating power is within.*

The contemplation of the progressive stages through which life is developed and matured in the egg, is highly interesting. The contents of the shells, of the species under immediate consideration, taken out and placed on a plate or a saucer on Mr. Bucknell's table, present the following appearances, according to the respective periods:—

On the third day, the embryo organisation of the skull, brain, heart, and blood is perceptible by the aid of a magnifying glass.

Fourth day. The pulsation of the heart is distinguishable by the naked eye.

Sixth day. The chief vessels and organs rudimentally formed; the pulsation and circulation of blood apparent.

Ninth day. Intestines and veins formed, and the deposition of flesh and bony substance commenced; the beak for the first time open.

Twelfth day. The feathers have protruded, the skull has become cartilaginous, and the first voluntary movement of the chick is made.

Fifteenth day. Organs, vessels, bones, feathers, closely approaching in appearance to the natural state.

Eighteenth day. Vital mechanism nearly developed, and the first sign of life heard from the piping chick.

Twenty-first day. The chick breaks the shell, and in two or three hours is quite active and lively.

The exit of the chick from the shell is assuredly one of the most interesting processes of animated nature ever investigated by naturalists. It was supposed that the mother bird broke the shell; but M. Réaumur has long since detailed the processes, and we ourselves have witnessed the evolution of the chick in the eccaleobion by its own unassisted efforts. The French naturalist to whom we have just now referred thus explains some interesting facts:—"I have seen chicks continue at work for two days together. Some again work incessantly; others take rest at intervals, according to their physical strength. I have observed some, in consequence of their impatience to see the light, begin to break the shell a great deal too soon; for they ought, before they make their exit, to have within them provision enough to serve for twenty-four hours without taking food, and for this purpose the unconsumed portion of the yolk enters through the navel. The chick, indeed, which comes out of the shell before taking up all the yolk is certain to droop and die a few days after it is hatched. The help which I have occasionally tried to give to several of them towards their deliverance has afforded me an opportunity of observing those which had begun to break their shells before this was accomplished; and I have opened many eggs much fractured, in each of which the chick had as yet much of the yolk not absorbed. Besides, some chicks have greater obstacles to overcome than others, since all shells are not of an equal thickness nor of an equal consistence; and I think it probable that the same inequality takes place in the lining membrane. The shells of the eggs of birds of various species are of a thickness proportional to the strength of the chick that is obliged to break through them.' (Domestic Habits of Birds, 'Library of Entertaining Knowledge.')

There is a caution to be observed in all cases regarding the eggs when the chicks are on the verge of maturity: they should not be stirred when within two days of the evolvement of the chicks. If any circumstances render it absolutely necessary to do so, care should be taken to place them with the broad end inclining upwards, as the beak of the chick is then in its proper position; and if this be reversed, the chick becomes unable to chip the shell, and must therefore die.

Chickens should be fed the day after their birth with crumbs of bread soaked in milk, or with the yolk of an egg boiled hard; and they will quickly learn to eat curds, grits, and barley-meal and milk. If not designed for immediate use, they should soon get raw corn, and occasionally alteratives of green food, such as bruised leeks, nettles, lettuces, &c. For the first week they should be confined to the house altogether: after that time they may be let out for a short time in the sun, and gradually habituated to the weather. To render the hen, which has already discharged her duty, still more productive to her owner, she is frequently confined to a coop, called in Surrey a *rip*, for some weeks after the chicks have seen the light. Her offspring during this time pass freely through the prison bars, returning at her call, or on occasions of alarm, to the maternal wings, and then hopping out again, to the inexpressible misery of their imprisoned mother, who is kept in this state of confinement until she becomes indifferent to the chickens and disposed to lay again.

The courage of the hen in defence of her offspring has been a common theme of admiration; the force of her maternal solicitude effects the most surprising change in her disposition and temper. Before she attained her matronly character, she was greedy, and always searching for food, fond of gadding about, and timid in the extreme. Now she becomes generous, self-denying, and intrepid; she assumes the fiery temper of the cock, and becomes a virago in defence of her helpless brood. An anecdote is told by White, in his 'Natural History of Selborne,' of the punishment inflicted by some hens upon a hawk which had at different times killed their chickens. By some means this hawk was caught, and the owner gave him up to the tender mercies of the bereaved mothers. In his own words, "Resentment suggested the laws of retaliation. He clipped the hawk's wings, cut off his talons, and fixing a cork on his bill, threw him down among the brood hens. Imagination cannot paint the scene that ensued; the expressions that fear, rage, and revenge inspired were new, or at least such as had been unnoticed before. The exasperated matrons upbraided, they execrated, they insulted, they triumphed. In a word, they never desisted from buffeting their adversary till they had torn him in a hundred pieces."

Poultry are the better for high feeding from the very shell, and on this account the heaviest corn is often far cheaper for them in the end than tailings, as regards the flesh, or the size and substantial goodness of the eggs. Young chickens may be put up for feeding as soon as the hen has ceased to regard them, and before they lose their first good condition. When chickens are wanted for domestic purposes, they are often left at liberty in the farm-yard, and if they have plenty of good food, they will be in the most healthful state for the table, and rich and juicy in flavour. Mr. Moubray ascertained that pullets hatched in March, if constantly high fed, laid eggs abundantly in the autumn; and if killed in the February or March following, were so excessively fat from the run of the yard as to open more like Michaelmas geese than chickens. Experienced poulterers will fatten fowls in two or three weeks with the aid of grease, which gives a luscious, but, in our judgment, a very disagreeable flavour to the flesh, which, though not actually diseased, is very inferior to that of the fowl fed at large in the common way at the barn door.

The practice of cramming poultry by the hand is quite common. A machine for this purpose is used in France, by which one man can cram fifty birds in half an hour. It is somewhat on the principle of a forcing-pump. The throats of the birds are held open by the operator until they are gorged through a pipe, which conveys the food from a reservoir below placed on a stool. In fifteen days, fowls are said to attain the highest state of fatness and flavour by this feeding. In addition to the ordinary paste of barley-meal, or meal made into little balls with milk, the dried seeds and leaves of nettles have been recommended by the continental poulterers, some of whom give a little henbane-seed to induce sleep, while others put out the eyes of the prisoners as the most effectual way of keeping them in a state of darkness, which is considered essential to their becoming rapidly fat; and under the pretext of relieving them from the irritation of vermin, they pluck the feathers from their heads, bellies, and wings. While fowls are thus preparing for the knife, though their bodies are closely confined, their hinder parts are free for evacuation and cleanliness, and their heads are at liberty to take in fresh supplies of nutriment.

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* 'Treatise on Artificial Incubation,' by W. Bucknell, Esq., p. 36.

The practice of making capons (emasculating the males) is practised a little in some of the English counties, and very much in France, where the females are also rendered incapable of breeding, and termed in their unsexed condition *poulardes*, in order to give them the tendency to fatten. An incision is made near the parts, and through this the finger is introduced to take hold of and bring away the genitals, but so carefully as not to injure the intestines: the wound is then stitched up and rubbed with oil or grease; and the comb (which appears to be an unnecessary and gratuitous pain and insult to the sufferer) is often cut off. The females are treated much in the same way, when they do not promise well for laying, or when they have ceased to be fertile; they are deprived of the ovarium. The subsequent treatment is similar to that in the former case. Care is taken to give them good food for three or four days, and during that time to keep them in a place of moderate temperature, to avoid the danger of gangrene, which, considering the time of the year—midsummer, when the operation is usually performed—is a very probable consequence. Pullets of the largest breed are selected for the purpose, as they yield the greatest weight to the poulterer; and if employed in hatching, cover the greatest number of eggs.

Cuvier states that the capon may be taught to hatch eggs and to act the part of a good nurse, with a little bell round his neck to supply the want of a good voice. He asserts that the natural courage and energy of this bird are not abated by the alteration of his condition, in which his audacity enables him to impose on the cocks and hens, so that they allow him to strut about with his former gait of consequential importance, and to fulfil his duties without interference or molestation. This seems incredible, as a bold and haughty spirit under such circumstances is unnatural in the extreme. The pallidness of his head and the diminutiveness of his comb and gills indicate the contrary disposition, and he is so despised by the other fowls that they will hardly condescend to roost with him.

Mr. Young, in his 'Report of the County of Sussex,' says that much art and attention are requisite to make capons, and that the Sussex breed are too long in the body for success in the operation, by which many are lost. A perfectly fat capon will weigh from seven to ten pounds.

As soon as the fowls are rendered sufficiently fat, they should be killed, or they will lose flesh and become unhealthy. The most humane and expeditious mode of putting them to death is by a smart blow with a blunt-edged stick, such as a child's bat, at the back of the neck. Higglers break the vertebræ of the neck by a sudden twist, and never bleed fowls, as this mode of dispatching them dries up the juices of the flesh. They bleed turkeys and geese however, after a stunning blow in the neck, not by cutting the throat, but by an incision in the upper part of the mouth.

Store fowls will feed well upon the tailings of corn, potatoes, and insects, and require little attention except when laying, during which time the food for the hens should be abundant, and their roosting-places dry and warm.

The diseases of all poultry principally arise from cold and moisture. Rheumatism decidedly arises from this cause. During or after moulting in a wet season, fowls frequently become diseased, as is evident from their drooping appearance, swelled and watery eyes, and the dropsical affections of the legs. Severe laying also sometimes causes emaciation and illness, which give way to a more healthy condition after the moulting season, if they have good food and dry weather.

Chickens are very subject, in wet or variable weather, to a disease called the chip, which appears in about a fortnight after their birth, when they are changing their feathers. Warmth and sunshine are the only restoratives within our knowledge.

The roup is properly an imposthume upon the rump, which is cured or relieved by opening, squeezing, and bathing with warm water. Mr. Moubray, however, who is a good practical authority, states that the roup is a general term for all diseases, though it is generally applied to catarrh, which is indicated by watery eyes and running at the nostrils. This last disease resembles glanders in horses, and is infectious, and generally fatal. As all these diseases originate in moisture, dryness and warmth are the best counteracting influences. The nostrils should be washed with soap and water, and the eyes with milk and water. Mr. Moubray recommends a pepper-corn in dough at first to impart warmth, and afterwards calomel three times a week as a finish to the cure.

We have had the trachea of a chicken dying of the gapes (which is the incipient stage of roup cut and opened, and have taken out narrow worms, about half an inch in length, which lay imbedded in a serous fluid. We have known fowls to be cured of the same disease by putting the upper part of a feather, stripped for the purpose, down the trachea, turning it round, and thus bringing up the worm.

The pip, which is probably a modification of roup, has been cured by an application of powdered borax dissolved in tincture of myrrh and water, and rubbed on the tongue with a camel-hair brush two or three times a day. This at the same time assists the bowels. The flux is not uncommon. Solid corn is the most certain remedy for this disease. Taken at the commencement, it is rarely serious, but if once established in the constitution it becomes incurable, and, according to some, contagious. For constipation, bran or pollard, with milk, beet leaves, and lettuces, afford a certain cure.

Much of the foregoing matter applies to the rearing and management of all poultry. The succeeding observations will be brief.

Turkeys.—The greatest weight to which our domesticated poultry can be made to attain is 30lbs., and a turkey of even half this weight is "a dainty dish."

"The varied plumage of the bird in the domesticated state is well known to every one; and in no species is that sure mark of subjection to man more strongly seen. Every gradation of colour, from its original bronze, passing into buff, and in many instances into pure white, may be observed in these strutting denizens of our farmyards." (Broderip, 'Recreations in Natural History.') The bronze or copper-coloured is not considered hardy, nor is it often reared, and the varieties may be stated to be only twofold, the dark-coloured and the light.

The dark-coloured birds are most prized for size and hardihood. Notwithstanding the great price which may be obtained for turkeys in London when fat, the finest young birds may be purchased in Ireland, fit for cramming, in September and October, from 4*s.* to 5*s.* a couple, and the light-coloured and smaller ones frequently from 2*s.* 6*d.* to 3*s.* 6*d.* a couple.

Turkeys, though extremely delicate in their infancy, become very hardy, and, if permitted, will roost on the highest trees, in the cold dry nights of winter, without suffering injury. The hen, which lays many eggs early in spring, sits thirty days, and covers from twelve to fifteen eggs. It is unnecessary for the turkey cock, as is the case with gallinaceous fowl, to be in constant intercourse with the hen during her period of laying. Two visits from him in that season are sufficient to impregnate all the eggs. She is a very steady sitter, and must be removed to her food and supplied with water, for she would never leave her nest. She wants the alertness and courage and sagacity of the common hen, and might be called a fool with much more propriety than the goose, which is an intelligent bird. The turkey hen is incapable of teaching her young ones how to pick up their food, on which account a poultry-maid should always attend them until they are reared.

On account of the constitutional delicacy of this bird, the hatching should not be commenced too early in the spring, and when the chicks are hatched they should be guarded from the extremes of heat and cold for some weeks. Rain is almost always fatal to them in their early stage. Curd, boiled eggs, and barley or oatmeal, kneaded with milk (or water, in case milk should produce looseness), potatoes, nettles, parsley, Swedish turnips, with chopped beet-leaves, after a little time, is their proper food. As they retain so much of their original wild nature as to stray a considerable distance, if permitted, the hen should be tied or cooped for at least six weeks, when the chicks will be hardy enough to follow her about, under the vigilant eye however of the poultry-maid, who should beware of their being caught by a shower.

They are soon familiarised to the society of fowls in the poultry or farm-yard. Without the advantage of the latter, it is an unprofitable speculation to rear any description of poultry on a large scale; but where a farmer's yard presents facilities, the economy of having all those kinds to which the soil and climate are suitable, is considerable. The only caution with regard to turkeys, where gallinaceous birds are numerous, is to have separate houses for them at night. These should be very lofty and well ventilated. They may be altogether open to the air in front, the doors being of trellis-work. Fowls (which are equally unsocial with the capons of their own kind) have a strong disinclination to roost with them.

When well-grown, turkeys supply themselves in their ramblings so far as to require food only when leaving their house in the morning and returning at night. The chances of rearing a second brood are not so great as to render it expedient to make the trial.

After six months turkeys may be crammed like fowls, but they require a much longer period to render them fully fat. Those great birds which are sent to the London market about Christmas, principally from Norfolk, frequently weighing from twenty to twenty-five pounds, are usually cocks from the preceding year. Great numbers of turkeys are reared in Ireland, where the climate is congenial to their nature.

Guinea Fowl.—This bird, which is not much larger than the common barn-door fowl, is of beautiful form and plumage, and though not a source of profit to the peasant who rears poultry for immediate sale, is usually kept where there is proper accommodation, as much on account of the excellence and abundance of the eggs (which, though small, are well-flavoured) as for the sake of the flesh, which is prized in the London markets when the season of pheasant-eating ceases. Th number of hens allowed to the male is about the same as among the gallinaceous family. The cock, little distinguished in appearance from the female, is an attentive and affectionate mate, and even obtrusively so to his favourites, whom he will attend to the nest, and remain with until they have laid their eggs.

Retaining some of their original wildness, Guinea fowl dislike the confinement of a house. For the purpose of laying, they prefer shrubberies, clover-meadows, or corn-fields, in which they will deposit their eggs, unless closely watched. The Guinea hen is fruitful during the entire summer, but not earlier than May. On this account, and the difficulty of rearing a late brood, it is more beneficial to keep her entirely for laying, and to put the earlier eggs under a common hen or capon, which will cover from twenty to twenty-five, than to encourage the incubation of the natural parent, which is moreover indisposed to it, especially if under cover. If left to her instinct, this bird would at a late season, in the open air, sit for the natural period, which is twenty-eight or twenty-nine days.

The cock, having the same dislike to incubation which characterises the male of pea-fowl, will destroy the eggs if he can discover them. Though the shell is remarkably hard, the chicks break through it at the proper moment, and are soon after as vigorous and ready to eat as the young of any other tribe of poultry.

The loud cry of these birds is not agreeable, but, like the scream of the pea-fowl, it announces with certainty an approaching change of weather. The hen utters a cry when she desires to roost, to call in her companions, to summon assistance, or to give notice of any of those alarms which her sensibilities cause her to express with such energy of voice, and in all which cases she is sure of receiving a ready sympathy.

The same food which is suited to the young of gallinaceous fowls and turkeys is good for the chicks of this kind; but as they are not often destined to the coops for fattening, a good deal of garden or field green-food may be combined with their grits, &c., after the first month. They have a great relish for insects of every kind, and thrive upon them as well as upon hemp-seed. When designed for the table, they ought to be killed at an early age, at which time the flesh is more juicy than that of other poultry of the same age, and very like that of the pheasant, though when old it becomes exceedingly tough.

Ducks.—The white duck, being the largest of the common domesticated kinds, is perhaps the best for the poulterer, though it is not deemed so delicate in flavour as the dark-coloured, such as that bred from intermixture with the Rhone duck, which is also large. The Muscovy variety is said to be a good breeder. One drake is sufficient for five females. It is generally believed that the duck lays no more eggs than she can cover (from twelve to fifteen), but Mr. Moubray states that, if well fed, some ducks will lay a great number, and he gives an instance of one laying an egg every day for eighty-five days.

For a fortnight after their birth ducklings should be kept from rushing into water, to which their instinct soon leads them; and with this view the mother is frequently confined (where there is any pond within her reach) to the rip, already described, which should be placed on a field of short grass, with a flat dish of water near it. The ducklings waddle about in search of insects, and at the maternal call return to the coop. This restraint upon the liberty of the poor mother should be avoided if circumstances permit, for to protract her close confinement after more than four weeks' sitting is a cruel restraint. It is very common to place duck-eggs under a hen, on account of her excellent qualities as a nurse.

Any kind of meal is good for ducklings at first, and this may soon be mixed with potatoes. The refuse of the kitchen will not only support but fatten them; but to have them quickly and highly fattened, they should have oatmeal made into paste. They will also devour any animal offal, and have no fastidiousness whatever. If allowed to follow a plough or attend on the gardener when his spade is at work, their greediness and activity in picking up worms are extreme; and for gobbling up snails and slugs and other such delicacies in the field or garden they are most useful, while they are at the same time putting themselves into high condition. Having no fastidiousness of appetite, they never require cramming, indeed they act as though they considered it their duty to get fat as quickly as possible, and therefore required no artificial aid.

In a poultry-yard the ducks and geese are frequently lodged on the lower floor of the fowl-houses, but it is better, if the locality will permit, to give them distinct chambers, particularly where a good pond (free from eels) is available; on the margin of this their huts may be placed with very trifling labour, and an invisible paling all round the water, constructed at bottom on the principle of the cage-trap, so as to prevent the ingress of rats or weasels, while it affords them a ready outlet, renders this department of the poultry establishment complete, though far too expensive for common adoption.

"Many families in Bucks derive a comfortable living from breeding and rearing ducks, the greater part of which, the early ones at all events, are actually brought up by hand. The interior of the cottages of those who follow the occupation presents a very curious appearance to the stranger, being furnished with boxes, pens, &c., arranged round the walls for the protection of the tender charge of the good wife, whose whole time and attention are taken up with this branch of domestic economy." (Moubray.)

Geese.—The proportion of females to the males is the same as in the duck tribe, and the period of incubation and the number of eggs that may be set correspond exactly. The goose lays in a mild spring very early, and on this account (but only with high corn-feeding in the previous winter, and stimulating food during the entire breeding season) two broods may be had in the same year. Unlike the peacock and the Guinea cock, the gander is not only indisposed to do any mischief to the nests, but is very attentive to the hatching birds, whom he vigilantly protects as he sits patiently by; nor is his protection, as he accompanies the goslings in due course, less creditable to his parental character. The goose is a very steady sitter, but usually rises often enough to drink and take sustenance, without its being necessary to remove her from the nest for the purpose.

The early treatment of the goslings is similar to that of ducklings. The mother should be penned up for some days upon dry grass, but neither too early nor very late in the day; beet leaves or other green food may be mixed even with the early diet, if immediate fattening be not the object.

Green geese are brought very early to the London market, and are worth at first from 8*s.* to 12*s.* each; they can be made quite fat with oatmeal and peas, and skimmed milk or butter-milk, when from four to six months old: many prefer oats alone.

The management of them in the vicinity of London is thus detailed in a communication to Mr. Moubray:—

"Cleanliness, punctuality, and regularity prevail; the business is conducted as it were by machinery, rivalling the vibrations of the pendulum in uniformity of movement. The grand object of preparing, not geese only, but poultry in general, for market, in as short a time as possible, is effected solely by paying unremitting attention to their wants; in keeping them thoroughly clean; in supplying them with proper food (dry, soft, and green), water, exercise ground, &c. On arriving at the feeder's, they are classed according to condition, &c.: they soon become reconciled to their new abode, and to each other. They are fed three times a day; and it is truly astonishing how soon they acquire the knowledge of the precise time; marching from the exercise ground to the pens like soldiers in close column. Goslings, or young geese, come to hand generally about the month of March, after which a regular and constant supply arrives weekly throughout the season. At first they are fed on soft meat, consisting of prime barley or oat meal, afterwards on dry corn. An idea prevails with many that any sort of corn will do for poultry: this is a grand mistake. Those who feed largely know better, and invariably make it a rule to buy the best. The Messrs. Boyce, of Stratford, whose pens are capable of holding the extraordinary number of four thousand geese, independent of ducks, turkeys, &c., consume twenty coombs of oats daily, exclusive of other food."

But though green geese bring an enormous price in the spring, if thoroughly fat, farmers generally find it more profitable to feed goslings on the stubbles, where they supply themselves with the best food without cost, and become sufficiently fat at Michaelmas, when ancient custom renders them a favourite dish. In the neighbourhood of the extensive commons in England great numbers of geese are kept.

Though young geese are subject to a disease called the cramp, the greater number of those which die in summer are destroyed by starvation, and the change from corn, and other nutritive food, to the miserable herbage which the fields and commons yield; and this constitutes their chief diet until the harvest season. Cold and wet weather are often fatal to them in the earlier months, if they be neglected. Much mortality also prevails amongst grown geese, wherever the horrible system of plucking them alive prevails, as in Lincolnshire and in Ireland. It is generally urged in excuse for this barbarity, that feathers are most elastic and valuable before the period of moulting, and that geese have been thus treated ever since feather-beds came into fashion. The offence carries some punishment with it; for it renders the flesh very tough, and in many respects deteriorates the value of a bird, if it does not destroy it altogether; but the immediate gain from the feathers counterbalances this and every humane consideration.

The cramming system is practised in France, when the object is to render the liver unnaturally enlarged by disease, with circumstances of great cruelty. We do not intend to give any information upon practices which we cannot recommend, and which we strongly condemn.

Eggs.—The most certain way of preserving eggs fresh is by greasing them with some unctuous matter, or immersing them in a strong solution of lime. In packing, they should be laid on end; for otherwise the yolks, preserving their centre of gravity, fall to the lowest side, and by adhesion to it become tainted sooner than if they were suspended in the centre. [Egg Trade.]

The only management, besides warmth and high feeding, by which a perpetual succession of eggs can be obtained in winter, is by having pullets and hens of different ages, which, moulting at different periods, are not all incapacitated from laying contemporaneously.

POUND. [Standard of Weights.]

POUNDAGE. [Subsidy.]

POWER. In Factorials, the manner in which the term *power* was introduced into arithmetic is seen. By definition, the fourth power of x means the product of four *xes*, or $x \times x \times x \times x$; and the same of other powers. But it is far more symmetrical to begin from unity;

and to say that the fourth power of x is the result of four multiplications by x, unity being understood as the commencement. Thus the successive powers of x, first, second, third, &c., are $1\times x$, $1\times x\times x$, $1\times x\times x\times x$, &c.: denoted by x^1, x^2, x^3, &c. And the term *root* is the inverse of power, as follows: If A be the mth power of B, B is the mth root of A, denoted by $\sqrt[m]{A}$. The peculiar algebraical character of the roots is explained in ROOT.

It is thus easily proved that when m and n are any two integers,

$$x^m \times x^n = x^{m+n};$$

that when m is greater than n,

$$x^m \div x^n = x^{m-n}.$$

Also that $x^m \times y^m = (xy)^m$,

$$(x^m)^n = x^{mn},$$

and that $\sqrt[n]{x^m} = x^{\frac{m}{n}}$,

whenever m is divisible by n without remainder. These rules, if applied in defiance of the restrictions first mentioned, lead to such results

$$\text{as } x^0,\ x^{\frac{2}{3}},\ x^{-4},\ x^{-\frac{2}{3}},\ \&\text{c.},$$

which are unintelligible so far as the definitions have yet been stated. Their proper interpretations [INTERPRETATION] are as follows: First, x^0 must be allowed to stand for unity, whatever x may be; secondly, x^{-n} must be understood to be $1\div x^n$; thirdly, $x^{\frac{m}{n}}$, m and n being positive integers, must stand for $\sqrt[n]{x^m}$. When these new definitions are added, all the rules remain true, whether m and n be positive or negative, integral or fractional: and the system of algebraic powers is complete.

An algebraic expression is said to be arranged in powers of a letter, say x, when the powers of that letter which enter are made to enter in ascending or descending order of algebraic magnitude. Thus $ax^2+bx^{-3}-x^4-x^{-1}$ is not at present arranged at all. To arrange it in ascending or descending powers of x, we must write it thus—

$$bx^{-3}-x^{-1}+ax^2-x^4,\ \text{ascending};$$
$$-x^4+ax^2-x^{-1}+bx^{-3},\ \text{descending}.$$

But even yet it is incomplete for many algebraical purposes, having no written indication of the fact that the ascent or descent is interrupted. Completely written in ascending powers, it should be

$$bx^{-3}+0x^{-2}-x^{-1}+0x^0+0x^1+ax^2+0x^3-x^4.$$

Written in this form, which may remind us of the use of a cipher in writing ordinary numbers, it is clear that we hardly read the expression less easily, and write it much more briefly, if we omit x and its powers altogether, and make some distinctive mark, analogous to the decimal point, between the parts which belong to the positive and negative powers. Thus the above might be written—

$$b+0-1+\ |\ 0+0+a+0-1,$$
$$\text{or}\quad -1+0+a+0+0\ |\ -1+0+b;$$

the mark | being on that side of the adjacent + or — which belongs to the positive powers. This mark however is not necessary in what follows.

The late Mr. Horner [INVOLUTION, &c.] was the first who suggested the systematic rejection of the ascending or descending powers. An example of multiplication and division will sufficiently explain its use. Suppose it required to multiply $7x^3-2x^2-3$ and $2x^4+x^3-4x-5$:—

$$\begin{array}{l}
2+0+1-4-5\\
7-2+0-3\\
\hline
14+0+7-28-35\\
\quad -4+0-\ 2+\ 8+10\\
\qquad\quad -\ 6+\ 0-\ 3+12+15\\
\hline
14-4+7-36-27+\ 7+12+15
\end{array}$$

Accordingly the answer is $14x^7-4x^6+7x^5-36x^4-27x^3+7x^2+12x+15$; and every stroke of the pen which the usual method contains, more than is in the preceding, is mere waste, and risk of error into the bargain. Now let it be proposed to divide $4x^6-3ax^5+2a^2x^4-11a^5x-a^6$ by $x^3+2ax^2-a^3$:—

$$\begin{array}{ll}
4-\ 3+\ 2+\ 0+\ 0-11-1 & (1+2+0-1\\
4+\ 8+\ 0-\ 4 & \quad 4-11+24-44\\
\cline{1-1}
\quad -11+\ 2+\ 4+\ 0 & \\
\quad -11-22+\ 0+11 & \\
\cline{1-1}
\qquad\quad 24+\ 4-11-11 & \\
\qquad\quad 24+48+\ 0-24 & \\
\cline{1-1}
\qquad\qquad -44-11+13-\ 1 & \\
\qquad\qquad -44-88+\ 0+44 & \\
\cline{1-1}
\qquad\qquad\qquad 77+13-45 &
\end{array}$$

Accordingly the quotient is $4x^3-11ax^2+24a^2x-44a^3$, and the remainder is $77x^2+13ax-45a^2$.

Mr. Horner himself did not live to print this suggestion, which, simple as it is, seems never to have been made before him. The possessor of his papers, Mr. T. S. Davies, of Woolwich, published some extracts from those papers in an appendix to a reprint of the paper on the solution of equations, which reprint appeared in the 'Ladies' Diary' for 1838; having previously introduced the simplification into the 11th edition of Hutton's Course. Since that time a paper on 'Algebraical Transformation,' sent by Mr. Horner to the Royal Society, but not* printed in the 'Philosophical Transactions,' has been published in the first and second volume of the 'Mathematician.' Details and examples are given in Mr. Davies' 'Solutions of Questions contained in Hutton's Course,' 1840, and in the 12th edition of that course, 1841.

But the greatest improvement in the operation of division, and one which contains the principle of a class of improvements, is one which Horner called the *synthetic method*, which amounts to deferring the actual steps of subtraction until they are wanted. If we were to proceed one step farther with the preceding division, -44 in the quotient would be followed by $+77$. This $+77$, if we look at all its components from the beginning, arises from $+0-11-0+88$. In like manner -44 arises from $+0+4-0-48$. Now arrange the process as follows:—

$$\begin{array}{r|l}
1 & 4-\ 3+\ 2+\ 0\ +\ 0-11-\ 1\\
\cline{1-1}
-2 & \quad -\ 8+\ 0+\ 4\ -11+24-44\\
+0 & \qquad\quad +22+\ 0\ +\ 0+\ 0\\
+1 & \qquad\qquad\quad -48\ +88\\
\cline{2-2}
 & 4-11+24-44\ |+77+13-45
\end{array}$$

Write the coefficients of the dividend horizontally a, b, c, &c., and of the divisor vertically p, q, r, &c., taking care to change the sign of every term of the divisor *except the first*.

$$\begin{array}{r|l}
p & a+\ b\ +\ c\ +\ d\ +\ e\ +\ f\ +\ g\ +\ h\\
\cline{1-1}
+q & \ +uq+ur+us\ +ut\ +\ vt\ +\ wt\ +xt+yt\\
+r & \qquad\quad +vq\ +\ vr\ +\ vs\ +\ ws+\ xs\ +ys\\
+s & \qquad\qquad\quad +wq+wr+xr\ +yr\\
+t & \qquad\qquad\qquad\quad +xq\ +yq\\
\cline{2-2}
 & u+\ v\ +\ w\ +\ x\ +\ y\ |+u'+\ v'+\ w'+x'
\end{array}$$

Divide a by p, giving u, and then write uq, ur, us, and ut in the successive columns which follow that of u. Make up $+b+uq$, the second column, and divide by p, giving v: write vq, vr, vs, vt, in the successive columns which follow that of v. Make up $c+ur+vq$ and divide by p, giving w: write wq, wr, ws, wt, in the columns which follow that of w, and so on. Then $u+v+w+$, &c., will give the coefficients of the quotient, and $u'+v'+$, &c., made from the columns which have not been used to find quotient terms, will give the coefficients of the remainder. For example, we want to find some terms of the quotient of x^4+1 divided by x^3+x^2-3x:—

$$\begin{array}{r|l}
1 & 1+0+0+0+\ 1\\
\cline{1-1}
-1 & \ -1+3+0+\ 0\ +\ 0+\ 0+0\\
+3 & \qquad +1-3+12\ -21+60\\
+0 & \qquad\qquad -4+\ 7\ -20\\
\cline{2-2}
 & 1-1+4-7+20\ |-41+60+0
\end{array}$$

Hence the quotient is $x-1+4x^{-1}-7x^{-2}+20x^{-3}$, and the remainder is $-41x^{-1}+60x^{-2}$.

When the first coefficient is anything but unity, fractions are introduced into the quotient. To avoid this, proceed as follows: Let a be the coefficient of the first term of the divisor. Multiply the successive coefficients of the dividend by $1, a, a^2, a^3$, &c.: turn the first coefficient of the divisor into 1, and multiply the second, third, fourth, &c., by $1, a, a^2$, &c. Proceed as above with the coefficients thus altered, and suppose that in the last line the quotient terms become $u+v+w+$, &c., and those for the remainder $u'+v'+$, &c. To find the true quotient coefficients write

$$\frac{u}{a}+\frac{v}{a^2}+\frac{w}{a^3}+\ \&\text{c.},$$

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* The Royal Society has been very unfortunate in its decisions about papers involving improvement of calculation. Horner's paper on equations was nearly rejected, and was only saved by the earnest remonstrance of Mr. Davies Gilbert. Barrett's improvement of life contingency calculations was rejected; so was Weddle's remarkable paper (afterwards published by himself) on the solution of equations by successive factors. Horner's paper on transformation was *withdrawn*, not rejected. The report on it set forth that Mr. Horner had proved himself the most able and the most dexterous of all who had recently investigated the solution of equations; but there was a doubt as to the methods of the paper being so much better than others, and possessing so much of novelty, as to fit them for the Transactions. The council were embarrassed: they could neither reject nor accept the paper; so they suggested that it should be withdrawn. It seems then that *better* methods than any in use were not fit for the Phil. Trans., unless the superiority was very decided. Now, first, this was a very unsound principle, and very unworthy of a scientific body; secondly, Mr. Horner's methods *do* possess a very decided superiority, as all who have used them know.

and for the true remainder coefficients write

$$\frac{u'}{a^m} + \frac{v'}{a^{m+1}} + \&c.,$$

where a^m is the last power used in the quotient terms, *repeated*, not the next one to it. Suppose, for example, we are to divide $x^3+mx^2+m^2x+5m^3$ by $2x^4+m^2x^2-3m^4$. Here, since x descends and m ascends regularly, we throw out x and m, and the abridged dividend and divisor become

$$\begin{array}{cccc} 1+1+1+5 & \text{and} & 2+0+1+0-3 \\ 1\quad 2\quad 4\quad 8 & & 1\quad 2\quad 4\quad 8 \end{array}$$

underneath which we have written the multipliers. Hence we begin with $1+2+4+40$ and $1+0-2+0-24$:

$$\begin{array}{r|l} 1 & 1+2+4+40 \\ \hline +0 & +0-2+0+24+48+48+864 \\ -2 & \quad +0-4+0+0+0 \\ +0 & \qquad +0-4-72 \\ +24 & \qquad\quad +0 \\ \hline & 1+2+2+36 \mid +20-24+48+864 \end{array}$$

Hence the quotient is

$$\frac{1}{2}\frac{1}{x} + \frac{2}{4}\frac{m}{x^2} + \frac{2}{8}\frac{m^2}{x^3} + \frac{36}{16}\frac{m^3}{x^4}$$

and the remainder is

$$\frac{20}{16}\frac{m^4}{x} - \frac{24}{32}\frac{m^5}{x^2} + \frac{48}{64}\frac{m^6}{x^3} + \frac{864}{128}\frac{m^7}{x^4}$$

One of the easiest modifications of this rule is the division of $ax^m+bx^{m-1}+\ldots$ by $x-p$ or $x+p$, as explained in FRACTIONS, DECOMPOSITION OF.

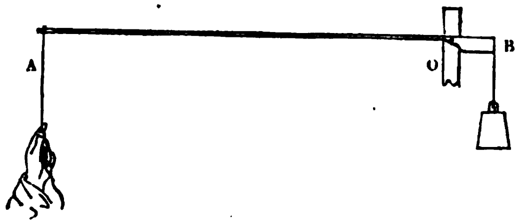
POWER (Mechanics). The present article is not intended to enter deeply into the subject, but only to remove various fallacies connected with the use of the word *power*, which frequently perplex and confuse those who attempt to study mechanics without the aid of mathematics.

The word *power* has obtained a technical meaning which seems to be almost peculiar to popular treatises. From among the numerous combinations which occur in machinery, the lever, the inclined plane, the wheel and axle, the pulley, and the screw have been selected, and named *mechanical powers*. Some have treated these as different principles; some have asserted that they are reducible to the lever and the inclined plane, others to the lever only; but it is generally asserted that all mechanical contrivance is reducible to one or other of these. To which of them the very powerful machine (in its way) which men call a *cannon* is to be referred we do not know, not seeing any great likeness in it either to a lever, an inclined plane, a wheel and axle, a pulley, or a screw. Again, the notions of the theories of these powers are as various as those of their arrangement: some say that all are creators of power, some that all are powers except the simple pulley, some that none are powers, some that they are losses of power. Those who deny that any of the adaptations above mentioned give power, look for their meaning of the word in the action of what are thence called *agents*, as in the muscular strength of men and animals, the force of wind, the fall of water, the expansion of steam or explosive gases, &c. Admitting that all these agents are well entitled to the name of powers, it is nevertheless difficult to refuse that name to a machine. Watch the effect of a large crane in unloading a vessel, compare it with what the same men could do by their unaided (or rather, unadapted) strength in the same time, and it will be impossible to deny that the machine gives power.

The cause of all this confusion and diversity of opinion as to the way of stating facts which every one knows, arises from the word power being taken in two different senses, that which is true of one of its meanings being untrue of another. In the first sense, power is gained whenever any thing is done quicker or better at the same expense, or in as effective a manner at less expense; whenever the advantage gained, or the disadvantage avoided, is worth more than the trouble and cost of the means employed. In the second sense, power is gained when a new adaptation is introduced, by which an existing agent is made apparently stronger. To find different phrases for these different things, let us say that power in the first sense means that which produces beneficial effect, and that power in the second sense means that which produces mechanical advantage: these last words have been often used by writers in the same sense as the technical word power.

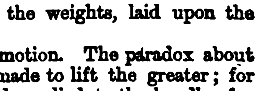
Beneficial effect may be produced in various ways, without mechanical advantage, but the benefit, as far as it is of a physical character, will generally be found to consist in a saving of useless labour. Thus, in the division of labour, than which nothing produces more of beneficial effect, there is not only the moral benefit, namely, the making the human agent fitter for his work by giving him a more limited range of occupations, but the actual saving of the labour of laying down one tool and taking up another. Again, when loaded carriages are dismissed down an inclined plane and made to draw up the empty ones, there is no gain in a mechanical point of view, for the momentum which is gained by the empty carriages is lost by the loaded ones; but the momentum lost by the loaded carriages is no loss, since there is no use in their delivering their contents with a great velocity, while the momentum abstracted is applied to a beneficial purpose. Thirdly, a simple pulley gives no mechanical advantage whatever, since the weight on one side, when the pulley is at rest, must be equal to that on the other. If however we compare the effect of this machine in raising weights with the carriage of them up a ladder, we see at once a beneficial effect, amounting to a saving of the greater part of the labour; for by using a pulley, the labourer has not to carry himself up to the height required and down again. Fourthly, when the traces by which horses draw are inclined at a proper angle, a part of the drawing power is taken off, and applied in lifting the carriage off the road and lessening the friction, so that the diminished draught is better able to do the remaining work than if the whole draught were applied to the whole friction. Here is no gain of power in the mechanical sense, though the alteration is certainly a double gain (no matter how slight a one) of beneficial effect, for the carriage is more easily drawn and the road is less worn. Numberless instances might be cited in which real benefit is a consequence of mere adaptation, even without the production of what is called *power* in treatises on mechanics.

In treating of the second meaning of the word power, or its synonyme, mechanical advantage, we must separately consider a machine just balanced, and one in which an additional force applied gives motion. Suppose a lever, one arm of which O A is ten times as long as the other O B, and suppose that the arms balance each other. A pull of one pound at A will then support (so it seems) ten pounds at B, for the first will certainly equilibrate the second, or prevent motion. Nevertheless, it is not true that one pound supports ten pounds; nor can one pound, by any contrivance whatsoever, be made to support more than one pound. In the case before us, A acts against one pound, but not one pound of B; it is A and B together, eleven pounds in all, which oppose a resistance of eleven pounds offered by the support or pivot O. The weight B is equivalent to two pressures, one downwards, at O, of eleven pounds, one upwards at A, of one pound. The frame on which the pivot rests neutralises the first, the pull at A neutralises the second. To say that A supports B, would be an assertion like that of a person who should say that he had paid 11*l.* with 1*l.*, and should forget that he had borrowed 10*l.* elsewhere; and in the above system there is neither gain nor loss of force in any manner. When the weight B is lifted from the ground, and attached to the end of the lever, and when at the same moment the hand was applied at A, there is a pressure of eleven pounds applied to the earth at O. But all this pressure was first taken from the earth, ten pounds of it by the removal of the weight B, and the remaining pound by diminution of the weight of the person pulling; for a person who pulls downwards at a rope in such a manner as to supply the place of a pound weight at the end of the rope, lessens his weight by one pound.



In the preceding manner it may be shown that every machine in which A, the less, balances B, the greater, is a case of the following kind:—B is equivalent to certain forces, P, Q, R, &c., applied at various points of the system, and to O, equal and opposite to A. Imagine P, Q, R, &c. and O substituted for B, then P, Q, R, &c. are counterbalanced by the resistance of the parts of the machine, and O, and O only, is counterbalanced by A. It may also be shown that the whole pressure upon the earth is just what it would be if the machine were dismantled, and its parts, together with the weights, laid upon the ground.

Let us now consider the machine in motion. The paradox about power here is, that the smaller weight is made to lift the greater; for example, that a pressure, say of one pound, applied to the handle of a crane, lifts a weight say of twenty pounds. As long as no more precise mode of expression is employed, the paradox continues:—the smaller weight *does* lift the greater. To take the simplest case, suppose that the descent of a smaller weight causes the ascent of a greater, as in an inclined plane with a pulley. It is now obvious that before the larger weight B can rise through A C, the smaller weight A must fall through a length equal to B C. In any machine in which the hand, exerting a pressure of one pound, balances a weight of twenty pounds, the hand when put in motion to raise the weight, will move twenty times as fast as the weight. It is then one pound moved through twenty feet,



which is mechanically equivalent to twenty pounds moved through one foot, and the paradox disappears. It is usual to express this by saying that what is gained in power is lost in time; but instead of this axiom, which only indirectly expresses the truth, it is better to say that a less weight cannot cause the ascent of a greater through a given height, without descending through a height greater in the same proportion as that by which the greater weight exceeds the less. Perhaps the easiest mode of balancing the power applied and the work done is as follows:—Suppose one pound descending through four feet raises four pounds through one foot, we have then applied the descent of one pound through one foot four times, and produced the ascent of one pound through one foot four times. The only difference is, that in the applied power it is the same pound which moves over four different feet, while in the produced effect there are four different pounds moving over the same foot. The machine is nothing but an adaptation which enables the agent to effect the exchange just mentioned. And though the common notion that a machine gives power usually has reference to the substitution of a greater weight with less velocity for a smaller weight with greater velocity, yet it frequently happens that the apparent power is gained by the contrary exchange, as in the common grinding-wheel and in the lathe. Frequently also the beneficial effect arises from a reservoir of power which is given out in small quantities, as in a clock or watch, in which the exertion of raising a weight or coiling a spring is expended in minute quantities over one or more days.

Without entering further into the preceding principle (for which, in its mathematical bearing, see VIRTUAL VELOCITIES), we will now touch upon some additional circumstances connected with the use of a machine, still confining ourselves to simple exposition of these circumstances, and avoiding mathematical explanation. Suppose a crane by which a man, with a certain amount of labour, raises five hundredweight through a height of ten feet, working all the while as if he were raising half a hundredweight, by a simple pulley, from the deck of a vessel to the wharf. If this five hundredweight were divided into ten portions of half a hundredweight each, and if each of these portions had a rope fastened to it, it would matter nothing, the manner of working being equally convenient in both cases, whether he raised the whole at once by the crane, or the ten portions in succession by their several ropes. This supposes that there is no friction in the parts of the crane, and that its wheels can be moved without any exertion when unloaded. Neither of these is true, for the friction of the loaded machine is considerable, and even the unloaded machine costs some exertion to set it and keep it in motion. So far then the balance is in favour of raising the ten subdivisions of the five hundredweight in succession; and we now see what those persons mean who say that a machine is a loss of power. But if we introduce the beneficial effect produced by the machine, we see that the subdivision of the weight is avoided, and that the labour thereby saved may be thousands or even millions of times that caused by the friction of the machine and the necessity of moving its wheels, &c. A little attention to such reasoning as the preceding will prevent the reader, however unpractised in mechanical considerations, from being led away by accounts of perpetual motion [MOTION] and of machines which are to work without power applied.

The muscular power of men and animals, the force of wind, the fall of water, the expansive power of steam, &c, are real powers, the explanations of which lie in the secrets of the laws of life, gravitation, and chemistry. A machine is an adaptation of material elements to one or more purposes, the life of which is one or other of the powers just mentioned. But nothing is more common than, in describing the wonderful effects of power and adaptation united, to lay the wonder on the wrong part. Thus we can imagine a person describing the progress of mechanics in the last century, by saying that "lace is made by steam, and mines which would be covered with water but for the application of science, are cleared for the miners by machinery." In the first instance the steam-power is but subordinate; horses or a water-mill might supply its place without any diminution of the extraordinary part, which is the adaptation of machinery to the performance of that which required so many and varied motions of the fingers. In the second instance, common pumps, or successions of them, would do as well as the machinery employed, if hands enough could be found to work them: the wonder is the introduction of labour to any amount by the help of steam. The vulgar notion is that steam, as steam, can adapt itself to anything, and that machinery, as machinery, can work.

POWER OF ATTORNEY. [LETTER OF ATTORNEY.]

POWER (Law). [USES.]

POZZUOLANO. A material used by the ancient Roman, and even by modern, hydraulic engineers for the purpose of preparing an artificial cement for works constructed in the sea. This material was originally obtained from the volcanic formations of the Bay of Puteoli, near Naples (from which circumstance the name itself is derived); but similar substances have been discovered in different parts of Italy and in other countries, and have been applied in the arts with equal success. In fact the pozzuolano is a dehydrized silicate of alumina, in which the silica exists in a state easily attackable by caustic alkalies, and is therefore capable at once of entering into a combination with the lime presented to it in the preparation of mortars, forming with it a double silicate of lime and alumina of an insoluble character; and substances of this description are very commonly met with in volcanic districts, wherein lava floods of a basaltic character have been poured out upon argillaceous beds. Thus in the environs of Rome itself the celebrated Catacombs were excavated in a large deposit of this argillaceous sand; in the island of Sardinia; in the south of France; in the north of Germany, near Andernach; and no doubt in countless other localities, the pozzuolano has been found under favourable economical conditions. The German material of this description is known in commerce under the name of *trass*, or *Dutch terras*.

Both the trass and the pozzuolano are used with the most favourable results when mixed with the purest and richest hydrates of lime; but the success of their application depends entirely upon the intimate nature of the mixture of the various ingredients, and upon the perfection of the hydration. These conditions can only be secured by the most perfect manipulation; and that again by the low price of manual labour; and it is on this account that the use of the natural cements, or of the artificial hydraulic cements, has been latterly introduced in most cases instead of that of the pozzuolano mortars which Smeaton and the earlier engineers so strongly recommended. But it is essential to remark (as was indeed before stated under MORTARS) that there are some conditions with respect to the state of the silicates of alumina entering into the composition of artificial cements, which are essential for their success; and, as far as our present means of analysis allow us to form an opinion on the subject, it would seem that these conditions are the most satisfactorily fulfilled when the combinations between the silica, the lime, and the alumina, are effected under great heat. This is actually the case with the Portland cements; and the very different results obtained by the mixture of the volcanically dehydrized silicates of alumina from those obtained by the mixture of underburnt brick earths, their chemical equivalents in nearly all respects, tend to confirm this opinion. It may be added that in Holland, Northern Germany, and in Italy, the pozzuolano class of materials is still used; but that in England they have so entirely been laid aside of late years as not easily to be obtained in the ordinary market.

Berthier gives the following analysis of the trass of Andernach and of the pozzuolano of Civita Vecchia:

Substances.	Trass.	Pozzuolano.
Silica	0·570	0·445
Alumina	0·120	0·150
Lime	0·026	0·088
Magnesia	0·010	0·047
Oxide of iron	0·050	0·120
Potash	0·070	0·014
Soda	0·010	0·040
Water and loss	0·144	0·096
Total	1·000	1·000

PRACTICE, a rule of arithmetic, appropriately so termed because it hardly contains any new principle, but depends for its application upon the memory and dexterity which the operator acquires from practice. Thus, in the following simple question, "How much do 40 yards cost at 18*d.* a yard," some arithmeticians (unpractised) might find it necessary to multiply 40 by 18 and divide the result by 12, for the number of shillings in the answer; but a practised arithmetician would immediately see that 18*d.* is a shilling and a half, so that 40*s.* must be allowed for the shilling, and 20*s.* for the half shilling, making altogether 60*s.* More complicated examples may require greater subdivision, but the method of proceeding has been completely described in the preceding. Suppose, for instance, it is required to find the price of 253¼ yards at 2*l.* 13*s.* 7¾*d.* a yard. The application of the rule of practice is as follows:—

At 1*l.* per yard 253¼ yards cost . .	£253	5	0	
			2	
2*l.* is 2 × 1*l.*	506	10	0	
10*s.* is ½ of 1*l.*	126	12	6	
2*s.* is ⅕ of 10*s.*	25	6	6	
1*s.* is ½ of 2*s.*	12	13	3	
6*d.* is ½ of 1*s.*	6	6	7½	
1½*d.* is ¼ of 6*d.*	1	11	7¾	½
¼ is ⅙ of 1½*d.*		5	3¼	¼
At 2*l.* 13*s.* 7¾*d.* per yard 253¼ yards cost	679	5	9½	¾

The process hardly needs more description than is given on the left; the only difficulty is the division of the price into portions each of which is a simple aliquot part of one of the preceding, and this difficulty is to be overcome by practice. It is also to be noticed that easy verifications often occur: thus, in the last process but one, it can easily be verified that 253¼ farthings is 5*s.* 3¼*d.* ¼.

When both the factors which are to be multiplied contain complicated fractions, this rule can be easily applied by turning the money factor into pounds and decimals of a pound, as in INTEREST. Thus, suppose it is required to find the price of 22 tons 17 cwt. 1 qr. 19 lbs., at 13*l.* 16*s.* 4*d.* a ton, or 13·81667*l.* We have then

1 ton . . costs . .	£13·81667
	22
22 ton "	303·96674
10 cwt. is $\frac{1}{2}$ of 1 ton . . .	6·90833
5 cwt. is $\frac{1}{2}$ of 10 cwt. . . .	3·45417
2 cwt. is $\frac{1}{5}$ of 10 cwt. . . .	1·38167
1 qr. is $\frac{1}{8}$ of 2 cwt. . . .	·17271
14 lb. is $\frac{1}{2}$ of 1 qr. . . .	·08636
4 lb. is $\frac{1}{7}$ of 1 qr.	·02467
1 lb. is $\frac{1}{4}$ of 4 lb. . . .	·00617
22 ton 17 cwt. 1 qr. 19 lb. cost .	£316·00082

So that the proper answer is less than a farthing above 316*l.* The preceding process is much shorter than the application of the rule of three, and also than a kind of double rule of practice once in use, which is not given in modern works, and is not worth revival.

This method of practice is also a convenient way of reducing fractions of weights or measures to decimals. Thus, if 17 cwt. 1 qr. 19 lb. is to be reduced to a decimal fraction of a ton, we have

1 cwt. is	·05	of a ton.
17 cwt. is	·85	"
1 qr. is $\frac{1}{4}$ of 1 cwt. or	·0125	"
14 lb. is $\frac{1}{2}$ of 1 qr. or	·00625	"
4 lb. is $\frac{1}{7}$ of 1 qr. or	·0017857	"
1 lb. is $\frac{1}{4}$ of 4 lb. or	·0004464	"
17 cwt. 1 qr. 19 lb. is	·8709821	of a ton.

PRÆFECTUS URBI (prefect or warden of the city), the title of a Roman magistrate, said to have been instituted by Romulus (Tacit., 'Annal.,' vi. 11) to supply the place of the kings in their absence from the city, within the walls of which he was for a time invested with kingly power, where he had the *imperium in urbe.* (Livy, i. 59.) He was appointed from among the senators. (Dionys., ii. 12.) During the time of the republic the præfectus urbi was appointed by the consuls, or by the senate (Dionys., viii. 64) when the consuls were obliged to be absent from the city. During the time of his office he exercised in the city the power of the consuls: he had the right to convoke the senate (Varro., 'Ap. Gell.,' xiv. 7, comp. with xv. 8) and to hold the comitia (Liv., i. 60). But in the course of time the prefect of the city was superseded by the prætor urbanus, on which the former magistrate became merely a shadow of what he had been, and was appointed while the consuls were absent from Rome for the purpose of celebrating the Feriæ Latinæ. This office, being of no importance, was often filled by young men, and Julius Cæsar even appointed several youths under age as prefects of the city. (Tacit., l. c., iv. 36; Dion Cass., xlix., p. 476.) This shadow of a magistrate seems to have continued to be appointed during the Feriæ Latinæ, even after Augustus had made a permanent præfectus urbi. (Suet., 'Nero,' 7.) Augustus invested this new prefect with considerable power, gave him the superintendence of public works, roads, aqueducts, the navigation of the river, and the corn to be distributed among the people. (Suet., 'Octav.,' 37; Tacit., l. c.; Dion Cass., lii., p. 547.) He was also invested with jurisdiction over slaves and turbulent citizens. He was thus something like a chief officer of the police; but his powers became gradually more and more extensive, so that almost all the powers formerly belonging to the office of prætor urbanus in the end were transferred to the præfectus urbi ('Dig.,' i., t. 12; 'De Off. Præf. Urbi,' comp. with Tacit., 'Annal.,' xiv. 41); and from the beginning of the 3rd century he not only exercised the inferior but also the criminal jurisdiction, and that not only in the city, but at the distance of one hundred miles from it. During the early period of the empire the prefect of the city seems always to have held his office for a number of years; but from the time of Valerian we find a new prefect almost every year. Respecting the titles by which he was addressed, see Brisson, 'De Form.,' p. 296. At the time when Constantinople was raised to the rank of second capital, it received a prefect of the city, who, like the prefect in the west, was the direct representative of the emperor, and next to him the first person in the city. The whole administration of the city, all its corporations and institutions, were under his superintendence; every month he made a report to the emperor of the transactions of the senate and people (Symmach., 'Epist.,' x. 44); in the assemblies of the senate he gave his vote before the consulars (Cassiod., 'Variar.,' vi. 4), and was the medium through which the emperors communicated with the city.

PRÆMUNI'RE (used for *præmonere,* "to forewarn," Co. Lit. 129 b) is the first word of an ancient writ by which a party was summoned before the sovereign to answer a charge of contempt against him. The commencement of the writ was as follows:—"Præmunire facias A. B. quod sit coram nobis," &c. The contempt consisted in the doing of some act in derogation of his allegiance; and in case of conviction, the judgment was, that the defendant should be thenceforth out of the king's protection, and his lands and tenements, goods and chattels, forfeited to the king, and his body should remain in prison at the king's pleasure. The word præmunire, as now used, has two meanings —one the writ itself, the other the offence to which the writ is applicable.

In late times it seems to have been considered that the offence was referrible only to attempts to introduce the papal authority into this kingdom; but it would appear that any attempt to introduce foreign jurisdiction or usurp upon the "kingly lawes of the crown" was equally within the penalties of a præmunire. Most of these attempts did relate to the papal jurisdiction, and the statute of præmunire (16 Rich. II., c. 5) relates only to such attempts. But the 27 Edw. III., c. 1, referred to by that Act, visits an analogous offence with the same penalty where one "shall draw any out of the realm in plea whereof the cognizance pertaineth to the king's courts, or whereof judgment is given in the king's courts, or which do sue in any other court to defeat or impeach the judgment given in the king's court, &c."

Numerous statutes have defined what shall be such a contempt as amounts to a præmunire. Most of the earlier are directed against *provisors,* as they were called, or persons who purchased from Rome provisions for holding abbeys or priories, &c., before those benefices were vacant (25 Edw. III., stat. 5, c. 22, stat. 6), or for exemption from obedience to their proper ordinary (2 Hen. IV., c. 3), or bulls for exemption from tithes (2 Hen. IV., c. 4), or those who held benefices in favour of aliens, &c. (3 Rich. II., c. 3; 7 Rich II., c. 12; 12 Rich. II., c. 15; 13 Rich. II., stat. 2, c. 2), or those who purchased (procured) bulls, sentences of excommunication, &c., against the king (16 Rich. II., c. 5). During the time of Henry VIII., several statutes applied the penalties of a præmunire to those who sued for or attempted to enforce any bull, &c., from Rome, or appealed there (23, c. 2; 24, c. 12; 25, cc. 19, 21; 28, c. 16), or refused to elect a bishop named by the king (25, c. 20). By 5 Eliz. c. 1, 13 c. 2, 27 c. 2, it was applied to those who refused to take the oath of supremacy, or defended the pope's jurisdiction, abetted publishers of bulls, &c., or sent relief to Jesuits beyond seas.

About this time the penalties of a præmunire ceased to be confined to the class of offences above referred to. The 13 Ch. II., s. 1, c. 1, made persons who advisedly assert that both or either house of parliament have a legislative authority without the king, and 4 Jac. I., c. 4, 1 W. & M., s. 1, c. 8, those who refused to take the oath of allegiance, guilty of a præmunire. By 7 & 8 Will. III., c. 4, serjeants, barristers, attorneys, &c., are subjected to the same penalties if they practise without taking the oath. By the 6 Anne, c. 7, a malicious or advised assertion that the then pretended Prince of Wales had any right to the throne, or that the king and parliament cannot make laws to limit the descent of the crown, amounts to the same offence. And 12 Geo. III., c. 11, attaches the same penalties to all such as willingly solemnise or assist, &c., at any forbidden marriage of the descendants of George II. The penalties of a præmunire have also been attached to persons guilty of offences of very different characters: to those who molested the possessors of abbey lands granted to Henry VIII. and Edward VI.; to brokers in any usurious contract, by 13 Eliz., c. 8; to those who obtained any stay of proceedings other than by arrest of judgment or writ of error in any suit for a monopoly, by 21 Jac. I., c. 3, s. 4; and to those who obtained an exclusive patent for the sole making or importation of gunpowder or arms, or hindered others from importing them, by 16 Ch. I., c. 21. By the Habeas Corpus Act, 31 Ch. II., c. 2, those who deprive or assist in depriving any subject of this realm of his liberty contrary to that Act, incur the penalties of præmunire; and by 6 Anne, c. 23, if the peers of Scotland convened to elect their representatives treat of any other matter, they are guilty of a præmunire. After the breaking of the South Sea bubble, those who thereafter engaged in such undertakings were, by 6 Geo. I., c. 18 (now repealed), made liable to the penalties of a præmunire.

The punishment of a præmunire has already been stated. After judgment, the defendant might formerly have been killed by any man. "But Queene Elizabeth and her parliament, liking not the extreme and inhumane rigor of the law in that point," made it unlawful to slay him. (5 Eliz., c. 1.) Still, being out of the protection of the law, he cannot sue in any action (Co. Lit., 129 b), and he forfeits all his goods and chattels, his lands and tenements in fee, and his life interest in lands in tail. (3 'Inst.,' 119, "Of Præmunire.") Prosecutions for this offence are now obsolete.

PRÆTOR, a word which apparently contains the same elements as the verb *præire.* The consuls were originally called prætors, but the name prætor was specially appropriated to a magistrate called the prætor urbanus, who was first appointed B.C. 365. He was called a colleague of the consuls, and was created with the same auspices. (Liv., vii. 1.) The prætor was at first only chosen from the patricians, as a kind of compensation to them for admitting the plebeians to fill one of the consulships. (Liv., vi. 42.) In the year B.C. 336 the first plebeian prætor was created.

The prætor, in his origin, seems to have been a kind of third consul. While the consuls were at the head of the armies in the field, the prætor exercised the consular power within the city, in the senate, and in the comitia. He also administered justice ("jus in urbe dicebat," Liv., vi. 42). On some occasions the prætor led the armies of the state. (Liv., vii. 23, &c.) Yet the imperium of the prætor was less than that of the consuls, to whom he owed obedience. There was also a distinction in his insignia of office, for the prætor had only six lictors, from which circumstance he is called by Polybius "the general with six lictors" (*ἡγεμὼν* or *στρατηγὸς ἑξαπέλεκυς,* and sometimes simply *ἑξαπέλεκυς,* &c.). It appears from Livy that the prætorship was originally given to a consul of the preceding year; and after the plebeians obtained admission to this magistracy, it was given alternately, at least for a time, to the patrician and plebeian consul of the preceding year. As the prætor was a kind of substitute for the consuls, there was nothing in the nature of the office which limited the number: and accordingly in B.C. 247, another prætor, called Prætor Peregrinus, was created, who administered justice in matters between citizens and foreigners, and in matters between foreigners only. It is conjectured that one prætor was a patrician and the other a plebeian, but this does not appear certain. If one of the prætors left the city to command the army, the other had the authority of both within the city; and when the military service required it, the imperium of a prætor was prolonged for another year by the senate or the comitia. When conquests were made beyond the limits of Italy, and foreign countries were reduced to the form of provinces, prætors were sent to govern them. Thus two new prætors were appointed for Sicily and Sardinia (B.C. 227), and subsequently two more when the two provinces of Spain were formed B.C. 197. The provinces of the prætors were determined annually by the senate, and distributed among them by lot. As the judicial labours of the prætors increased, they generally spent their year of office at Rome, and then took the charge of a province with the title of proprætor. Sylla increased the number of prætors to eight. The prætor urbanus had the highest rank, and was specially called prætor: the duties of his office required his constant attendance at Rome, and he could not leave the city for more than ten days at a time. He had the troublesome and expensive duty of superintending the Ludi Apollinares and giving gladiatorial shows to the people. Julius Cæsar increased the number of prætors to ten, then to twelve, fourteen, and sixteen; Augustus reduced the number to ten, then again raised it to sixteen, and finally fixed it at twelve. Under Tiberius there were sixteen. A permanent prætor for fidei commissa was subsequently appointed (‘Dig.’ i., tit. 2, s. 3), and another for matters between the Fiscus and private individuals; and a prætor was appointed by the emperor M. Antoninus (Capitol. ‘M. Anton.,’ c. 10) solely for matters relating to guardianship (tutela). The office continued in Rome with varying numbers and powers till the fall of the Western empire. At Constantinople it endured somewhat longer.

An office like the prætorship in some respects may be traced farther back than the first election of a prætor; and the vicarious duties of the office appear clearly in the functions of the ancient præfectus urbi [Præfectus Urbi], whose office became of less importance on the appointment of the prætor urbanus. As late as the time of Cicero (‘Ep. Fam.,’ x. 12, xii. 28), we find the prætor performing the duties of the consuls in their absence.

Under the republic the prætor urbanus became the chief magistrate for the administration of justice, and in this respect his office was the most important in the state. He was one of the magistrates who had the Jus Edicendi (Gaius, i. 2), or of publishing edicta, which were the foundation of a body of law known under the names of Jus Honorarium or Prætorium. The prætor peregrinus had also the Jus Edicendi: and the edicta of these two prætors formed the largest body of this edictal law. The edicta of the prætor urbanus were published generally on entering on his office, and occasionally during its continuance. It is difficult to describe the edicta in exact terms, but they had reference only to civil actions, and their object was generally to provide for cases unprovided for by the existing laws, and mainly by introducing new kinds of actions (actiones utiles) when the actions of the old law (actiones directæ) did not apply, and fixing the mode of procedure. They often adapted a new form to an existing right, and they contrived by various legal fictions to accommodate the limited provisions of the old laws to the existing wants of society; but in all these proceedings we clearly discern a rectitude of intention and singleness of purpose as the characteristic of the edict. The prætor also interfered in a summary way by his Interdict, particularly in matters of possession [Possession], in the case of a man who was of unsound mind and incompetent to manage his property, or a prodigal who was wasting his substance; in which cases the prætor appointed a curator, when the laws of the Twelve Tables had not provided for one. He also gave relief in cases of fraud whenever the law had made no provision (‘Dig.’ 4, tit. 3), and generally by the doli exceptio and the in integrum restitutio, in the case of minors, he set aside fraudulent transactions. (Savigny, ‘Von dem Schutz der Minderjährigen,’ Zeitschrift x. 261.) It is stated that the prætors would sometimes vary their edicta in the course of the year, till this was forbidden by a decree of the senate, and finally by a lex Cornelia (B.C. 67). This gave to the edict a character of greater stability. It seems that the edicta of his predecessors, though not absolutely binding on an actual prætor, were frequently adopted by him. Indeed we cannot conceive that the prætorium jus could have acquired that stability and consistency which it undoubtedly had acquired, even in the time of Cicero (‘Leg.’ i. 5), if the chief rules that were established by the prætors were not observed by their successors. The Roman jurists found ample matter for comment in the prætors' edicta, and a large part of their writings had for their object the exposition of the legal principles contained in them. Under the emperor Hadrian the edicta of the prætors were collected and arranged by Salvius Julianus, a distinguished jurist, under the name of Edictum Perpetuum, and from this time the progressive development of the Roman law by the prætors' edict ceased. The constitutions and rescripts of the emperors supplied the place of the edict; the importance of the functions of the prætors was greatly diminished; but they still presided in quæstiones or judicial inquiries into crimes, or that class of offences which were the subject of judicia publica. Sometimes persons (quæsitores or quæstores) were appointed on special occasions to preside at such trials. After the number of prætors had been increased to six, the prætor urbanus and peregrinus exercised their usual jurisdiction, and the other four presided in quæstiones as to repetundæ, peculatus, majestas, and ambitus. These quæstiones were called perpetuæ (Cic., ‘Brut.,’ 102), apparently because the prætors exercised the functions of quæstores during the whole year of office, and not, as was the old practice, on the particular occasion only of their appointment as quæstores. Still extraordinary quæstores might be appointed. Sulla, by various leges, added to the number of quæstiones perpetuæ, and at the same time made two additional prætors, and when their criminal jurisdiction was withdrawn, their functions were little more than formal.

PRÆTORIANS was, in the time of the Roman republic, the name of a select cohort which attended the person of the prætor or commander of a Roman army. Sallust (‘Catilina,’ 60) says that Petreius, finding that Catilina and his followers defended themselves more stoutly than he expected, ordered, as a last expedient, the prætorian cohort to charge the insurgents, and this decided the fate of the battle. In the time of the triumvirate, Octavian and Antony greatly increased the number of the prætorians. Appianus (‘Bell. Civ.’) says that after the battle of Philippi they dismissed all those soldiers who had served their time, except 8000 men who requested to remain in the service, who were distributed in prætorian cohorts attached to the persons of the triumvirs. After the final overthrow of the republican party, Augustus formed the prætorians into nine cohorts, and Tiberius fixed their station in the capital as guards to his person. (Suetonius, ‘August.,’ 49.) They became in fact, under the emperors, what the regiments of guards or household troops are in the actual monarchies of Europe, a select and privileged body in the army. But besides their ordinary military duties, they had also the charge of state prisoners, and often acted as executioners. The prefect of the prætorium was the commander of the whole body of prætorians. They were all picked men, chosen from Old Latium, Umbria, Etruria, and the older Roman colonies, and they were proud of their origin. (Tacitus, ‘Annal.,’ iv. 5.) Under Vitellius the prætorian cohorts were increased to sixteen. (Tacitus, ‘Hist.,’ ii. 93.) In the frequent revolutions of the empire the prætorians acted a conspicuous part, and often determined the fate of an emperor, and the choice of another; as in later times the janissaries did with regard to the Turkish sultans. Diocletian reduced the number of the prætorians, and Constantine entirely disbanded them.

PRAGMATIC SANCTION. [Charles VI. of Germany, and House of Habsburg in Biog. Div.; and Treaties, Chronological Table of.]

PRAIRIES. [Plains.]

PRAYER, a term in theology, used to designate the intercourse passing between human minds and the divine. Language appears not to be necessary to complete the idea which the word represents, since we speak of mental prayer, which is thought directed heaven-wise in adoration or in entreaty without the sentiment of the mind being embodied in words or finding expression by the lips. But its far more common use is to express this kind of intercourse when the sentiment of the mind is embodied in language.

It is a derivative of the verb to *pray*, which signifies to ask for something, and the intercourse of which we have spoken is described by a word which etymologically describes only one part or section of the whole idea, inasmuch as in such intercourse the principal object will always be the supplication of those rich communications of good which God can bestow and man receive.

Prayer springs immediately out of the persuasion that man is not placed on this globe without a protecting and governing power over him, which power is conceived to belong to the One Great, Good, and Wise Being, who was the Creator at first of man himself, and of all the things by which he is surrounded, or which touch in any way his condition. Wherever this idea is fully formed, it seems that the mind must, occasionally at least, fall into the disposition to entreat that the Power, which can do so much for it, would be pleased to exert itself. Whether this government and this ability be vested in some one being, or be supposed to be distributed among many, either equal in power, or supreme and subordinate, the case is the same. Circumstances arise in which it seems that it would be impossible to withhold the mind from assuming the form of supplication and the lips from expressing the desires which have sprung in the mind. We accordingly find that prayer has existed from the earliest times when we find men raised into the rank of religious beings, and in any state of religious knowledge, however rude and mistaken the ideas may have been; in times of danger and calamity at least, men have thrown themselves prostrate before a superior power, and intreated its interposition.

Sometimes the prayer may be no more than a brief ejaculation; but if arising in the sincerity of the heart, it is not the less prayer, nor the less regarded by Him who is described in the Holy Scriptures as the God that heareth prayer.

But even in some of the earliest monuments of human thought and feeling we have prayer that has not been mere ejaculation, or even the mere expression of feeling excited by temporary emergencies: and there are come down to us various prayers used by good men in ancient times expressive of their desires, and at the same time showing how other topics may properly be introduced and mingled with supplication. There are prayers of men who had not the light of either of the divine dispensations, and there are wise directions concerning prayer in the writings of such men; but the Scriptures, both of the Old Testament and the New, contain many prayers, and many hints and observations respecting prayer, all of which are very instructive, and held in devout reverence by those who receive the persons whose words are there recorded as examples and authorities.

From these examples, and from the instructions incidentally given, Christian divines have deduced certain principles respecting prayer. They have in fact raised a kind of system of prayer: dividing and subdividing the several branches of it. Of these it will be sufficient to say that a prayer, or a body of words expressive of the intercourse, should contain (1) expressions of adoration and admiration of the Mighty Being who is the object of address, by which the mind is brought into a state of confidence that he can grant that which we entreat of him: (2) expressions of our own unworthiness to receive more blessings than he has already seen proper to bestow upon us; either on account of a general persuasion of demerit, or of some particular sin of which we have been guilty. This is thought to be in accordance with the actual state of every one who thus puts himself as it were more immediately in the awful presence of his governor and judge, and to be also salutary to the suppliant as keeping up a sense of proper humility, and a disposition to acquiesce in whatever may be the divine will. (3) Then comes the supplicatory part, in which general or particular blessings are besought, suitable either to the general condition of the person praying, or to the particular circumstances of the moment. (4) Intercession for others, the entreaty of the divine favour for the whole human race, and such blessings as particular classes of persons peculiarly need. This is thought necessary as cherishing the kind and charitable feelings, and leading each individual man to feel himself but as one of a great family of whom God is the common head and the common protector, and whose interests are not to be disregarded in attention to the wants and wishes of an individual member of it. (5) Lastly comes thanksgiving, a devout acknowledgment of past and present mercies, the good which God has given in his natural providence in general, or any special good which he may have granted. Such, according to Christian divines, ought to be the form into which men's thoughts cast themselves when they enter into communion with God: and the various prayers which are delivered in public by the ministers of religion in behalf of multitudes praying together, are for the most part constructed in this form, the differences arising (1) from the selection of different subsidiary topics under each, and (2) from the greater length in which each of these subjects is entered into, according to the feeling or the notions concerning prayer of the individual minister; and such also are the prayers for the most part in those collections of prayers many of which are printed for the use of persons, either in their private or family devotions, who find a difficulty in embodying in words the sentiment of the heart.

Liturgies are of the nature of printed collections of prayers. They are guides to the mode in which the prayers of many assembled in Christian congregations shall be offered. The Book of Common Prayer contains the Liturgy of the English Church as appointed by authority. The effect of liturgies in public worship is to restrain the manifestation of peculiarities in the notions of particular ministers respecting the nature and subjects of prayer: to keep out of the public assemblies of Christians extravagancy and enthusiasm; to bring the will of the community at large to bear on the wills of single ministers in respect of the devotional part of public worship; and to make known beforehand to the people what sentiments will be expressed, and in what form of words, in the service in which they are about to engage. [LITURGY.]

PREBEND, derived from the Latin word *præbeo* (to minister to, or yield), is an endowment in land, or pension in money given to a cathedral or conventual church *in præbendam*, that is, for a maintenance of a secular priest or regular canon, who was a prebendary as supported by the prebend. It is named from the land or other source whence the profits attached to it are derived.

A simple prebend was one which had only its revenue for its support; a prebend with dignity, one to which a jurisdiction was annexed; a prebendary holding the latter was styled a dignitary. Some prebends were donative, others in the gift of laymen, who, in case of vacancy, must have presented the future prebendary to the bishop; on this the bishop instituted him, and the dean and chapter then inducted and placed him in a stall in the church. If a bishop were the patron, he collated. At Westminster the king collated by patent, by virtue of which the prebendary took possession without institution or induction. A mandamus lies to compel an election to fill a vacancy. During a vacancy the profits belonging to a prebendary as sole corporator went to his successor; those which he held as member of the corporation aggregate were divided among the dean and chapter. A prebend being a benefice without cure of souls, was not formerly incompatible to be held with a parochial benefice, but one prebendary could not possess two prebends in the same church, though he might hold a second in any other. But now, by 1 & 2 Vic. c. 106, no spiritual person holding more benefices with cure of souls than one shall hold any cathedral preferment; or, holding any cathedral preferment and also any benefice with cure of souls, shall hold any other cathedral preferment; or, holding any preferment in any cathedral or collegiate church, shall hold any preferment in any other. (Comyns's 'Digest,' tit. 'Eccl. Persons,' iii. 600; Burns, 'E. L.,' 88, 90; Rogers, 'On Ecclesiastical Law, tit. 'Dean and Chapter.' [DEAN.]

By the 3 & 4 Vic., c. 113, founded on the Report of Commissioners appointed to consider the state of the church with reference to its revenues, very important changes were made relative to cathedral preferment. The statute does not affect existing interests. Its provisions, in general terms, are as follows:—Henceforth all the members of chapters are to be styled canons. Provision is made for the suppression of many existing prebends, the creation of one additional for St. Paul's, and ultimately all cathedral and collegiate churches as to number of canons, are to be placed upon the following footing:—Canterbury, Durham, Ely and Westminster 6 each; Winchester and Exeter 5; Bristol, Carlisle, Chester, Chichester, Gloucester, Hereford, Litchfield, Lincoln, Manchester, Norwich, St. Paul's, London, Peterborough, Ripon, Rochester, Salisbury, Wells, Windsor, Worcester, and York, 4 each; and St. David's and Llandaff 2 each.

All bishops are authorised to confer honorary canonries, without emolument, to the number of twenty-four, in each cathedral church.

No canon is, by virtue of his canonry, for the future to possess any separate estate or income, all of which are to vest in the Ecclesiastical Commissioners appointed by 6 & 7 Wm. IV. c. 77. The profits of the suspended canonries are to be paid to the commissioners, in whom their estates, as well as those of non-residentiary prebendaries, &c., are to vest. The annual incomes are also fixed by this statute. The separate patronage of members of chapters is to be vested in the respective bishops. Provisions are made as to the exercise of the patronage of chapters. The minor canons are to be appointed by the chapter.

PREBENDARY ('Prebendarius'), one who has a prebend [PREBEND], a canon endowed with land or an advowson or tithe. In right of his prebend, he possessed an estate. He was bound by canon 42 to residence four score and ten days during each year. The time fixed by 3 & 4 Vict. c. 3, is three months. The whole body attached to each cathedral or collegiate church forms, with the dean, a corporation aggregate, called the dean and chapter. Each prebendary, having a distinct estate, is, by virtue of that, a sole corporator, as well as member of the corporation aggregate. The office of the dean and chapter is to consent to the grants, leases, &c., of the bishop. Anciently they formed his council, as they still do nominally. On his death they certify the king of it in chancery, upon which a congé d'elire is issued. During the vacancy, they govern the diocese and guard the spiritualities of it, unless where the archbishop has that right by prescription. Prebendaries were bound by canon 43 to preach in their churches, and in other churches in the diocese, especially those whence their profits proceeded, or to substitute other preachers approved by the bishop. A prebendary could not make a grant, &c., until after installation and induction. [DEAN; CHAPTER.] (*Termes de la Loy*, tit. 'Prebend,' 'Chapter;' *Com. Dig.*, tit. 'Ecclesiastical Persons.')

PRECEDENCE, one of the artificial distinctions among men living in a state of political society. In all countries the great mass of mankind will be of one level, no individual possessing political privileges which do not belong to the rest, except as pertaining to some particular employment in the various ordinary businesses of life in which each individual is engaged. But these give no precedence of one before another; all move on abreast. But above these are certain persons, such as the members of the liberal professions, persons who hold or have held offices in the state, peers, who take precedence of the rest, and who are allowed to do so, if not by any law absolutely promulgated, yet by the constant usages of society. And again, the individuals, who may form perhaps the thousandth part of the whole community, who possess this privilege of precedence, have the precedence amongst each other regulated according to usage, or, in other words, by the precedents established in records of former arrangements. The subject is one to which a good deal of attention has been paid, and it is now only as an incident to the creation of new courts or officers, or in singular positions of the royal family, that difficulties arise. The members of the College of Arms, who are the council of the earl-marshal of England, are usually referred to in questions of precedency; and to them is assigned the arrangement of public processions, as at royal marriages, funerals, coronations, and the like, when it is that questions of this kind come to be considered.

Tables of precedency may be seen in many books, and especially in those called Peerages.

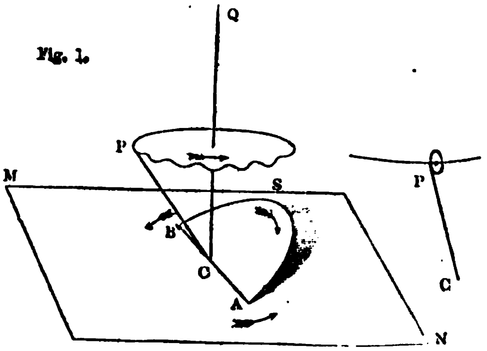
Sometimes the question arises among ambassadors who shall enter a room or depart before another, and great tenacity has at times been manifested in supporting the claims to rank of the state or kingdom represented. In the 'Philoxenis' of Sir John Finet there are some almost ridiculous instances of the struggles made for precedence by ambassadors of the state of Venice in the reign of James I.

PRECESSION AND NUTATION, the abbreviated way of expressing the precession of the equinoxes and the nutation of the earth's axis.

These phenomena should always be considered in connection with the rotation of the earth, of which they really form a part; that is to say, diurnal rotation, precession, and nutation are the motions of the earth about its centre, independently of the motion of that centre along its orbit round the sun. It will assist our comprehension of the subject to suppose the earth's centre a fixed point, the relative motions of the heavenly bodies being adjusted accordingly. [MOTION.]

The rotation of the earth round its axis is visible from hour to hour by the change of place in the stars: the precession and nutation are motions of too slow a nature to be rendered visible, and indeed could hardly be made so unless the ecliptic and equator were visible circles. If such were the case, and if the motions were large enough, the equinoxes, or intersections of the equator and ecliptic, would appear to change place, the equator moving slowly round the ecliptic with a retrograde motion, that is, contrary to the annual course of the sun. The equinoxes would appear to move with a variable motion, sometimes a little faster and sometimes a little slower than the mean motion. At the same time the equator would appear to swing backwards and forwards to and from the ecliptic, turning upon the equinoxes as pivots. Of these motions the average motion of the equinoxes upon the ecliptic is the precession; the alternate acceleration and retardation is one part of the nutation; and the alternate increase and diminution of the angle contained between the two is the other part. It is however common to call the acceleration and retardation of the motion of the equinoxes by the name of the equation of the equinoxes, and to reserve the name of nutation for the motion of the pole which corresponds to it.

Fig. 1.



Let C be the centre of the earth, C P half its axis, P the north pole, and A S B half of the equator. Let M N be part of the plane of the ecliptic, and C Q a line perpendicular to it, pointing therefore to the pole of the ecliptic in the heavens: and let the direction of the diurnal rotation be that of the arrow marked on the equator. If then P were carried uniformly round a circle perpendicular to C Q, so that C P should describe a conical surface, the equinoxes B and A would be carried round in a direction contrary to that of the diurnal motion, and with them the equator B S A, the angle which the equator makes with the ecliptic remaining unaltered. This motion of B and A is the precession. But suppose that instead of P being placed on the circle, it is placed on the circumference of a small oval, which has its centre on the circle. While the centre of the oval moves forward on the circle with the motion of precession, let the pole P move round the oval with a motion much slower than that of the precession. It will then trace out in space an undulating curve, as shown in the principal diagram, and the effect will be an alternate retardation and acceleration of the motion of the equinoxes along the plane of the ecliptic, together with a vibration of the plane of the equator to and from the ecliptic; which are the motions described as constituting the nutation.

The preceding is a description of the effect of any one of the heavenly bodies, theoretically speaking, upon the axis of the earth. The whole precession and nutation is the united effect of the sun, moon, and planets. The effect of the planets however is insensible, except in a slight annual alteration of the plane of the ecliptic, which is mixed up with the precession, and makes it appear a very little smaller than it would be if the system of the sun, moon, and earth were undisturbed by the planetary attraction. The general reader need only attend to the main phenomenon, namely, that the equinox (the point of the heavens at which the sun is at the commencement of spring) moves slowly * backwards along the ecliptic, at the rate of 50¼ seconds per annum, or about 14° in one thousand years. This rate of motion is subject to a very slow increase, which is not perhaps sufficiently well determined to make it worth while to compute exactly the time in which the equinox describes the whole heavens, a period of between twenty-five and twenty-six thousand years.

A good notion of precession may be got from observing the spinning of a top. As long as the axis of the top is not vertical, this axis itself revolves, but much more slowly than the top revolves round its axis. Let the top be supposed to remain with its axis at one angle to the vertical, except only a slight balancing motion to and from the vertical, and let the conical motion of the axis be slightly accelerated and retarded; this will give a complete notion of the phenomena of precession and nutation.

Before proceeding to the mathematical and physical description of these phenomena, we shall show the manner in which they may have an historical and chronological importance. Let the reader take a globe or a map of the stars, he will see that the ecliptic crosses the equator under the tail of one of the Fishes, so that the vernal equinox is nearly in a line with the stars α Andromedæ and γ Pegasi (Alpheratz and Algenib). These stars then are invisible at the beginning of the spring, being in the region of the heavens nearest to the sun. Let from twelve to thirteen thousand years elapse, and the slow precessional motion of the equinoctial points will reverse the positions of the equinoxes, so that the above-named stars will be near the meridian at midnight at the commencement of spring, as the stars in the head of Virgo are now. An Aratus of our day would celebrate the brightness of Virgo in the nights of spring, while one of thirteen thousand years hence must choose Pisces for that purpose. The seasons of the year at which different stars begin to be distant enough from the sun to shine brightly is undergoing a gradual alteration. Hesiod, for instance, says that in his time and country Arcturus rose at sunset in sixty days after the winter solstice; Newton calculated that this took place about B.C. 870, which is one of his reasons for supposing that the poet was alive about that time. The phenomenon however is itself rather vague, and Hesiod may be supposed not very exact in his description. It is generally considered that Newton attached too much importance to such data in settling his system of chronology.

About two thousand years ago the equinox was twenty-eight degrees more advanced among the signs, and was near the beginning of the constellation Aries. It was about this time that the precession of the equinoxes was discovered by Hipparchus [ASTRONOMY; HIPPARCHUS, in BIOG. DIV.], and since that time the vernal equinox has preserved the title which it properly held at the time when its motion was discovered, namely, the first point of Aries. Certain astronomical fictitious constellations have been made to move with the equinox, at least until lately; counting from the equinox, the first thirty degrees of the ecliptic have been always called Aries, the second thirty Taurus, and so on. Thus when an astronomer of the middle ages asserts the longitude of a star to be ♎ 18° 22′, he means that it is in 18° 22′ of the astronomical Libra, a constellation supposed to begin at 6 × 30° or 180° distance from the vernal equinox. An astronomer of our day would say the star's longitude was 198° 22′.

Taking the beginning of the year 1750 as the starting point (as is generally done since the publication of the 'Mécanique Celeste'), and calling it the number of years elapsed, the whole motion of the equinoxes from precession, including the effect of the planetary action on the ecliptic, is

$$50''{\cdot}176068\ t + 0''{\cdot}0001221483\ t^2,$$

while the precession in one year is

$$50''{\cdot}176068 + 0''{\cdot}0002442966\ t.$$

M. Bessel substitutes 50″·21129 for 50″·176068.

The obliquity of the ecliptic, assumed at 23° 28′ 18″ in 1750, is

$$23^\circ\ 28'\ 18'' - 0''{\cdot}48368\ t - 0''{\cdot}0000272295\ t^2;$$

its yearly diminution, arising from the planetary action, independently of nutation, being

$$0''{\cdot}48368 + 0''{\cdot}0000054459\ t.$$

M. Bessel takes 23° 28′ 17″·63 for the obliquity in 1750, and uses 0″·457 instead of 0″·48368.

The nutation affects both the place of the equinoxes and the obliquity of the ecliptic. Let $\Delta\lambda$ denote the nutation in longitude, $\Delta\epsilon$ the effect upon the obliquity of the ecliptic. Then, according to Professor Peters ('Numerus Constans Nutationis'),

$$\Delta\lambda = -17''{\cdot}2491 \sin \text{☊} + 0''{\cdot}2073 \sin 2\,\text{☊} - 0''{\cdot}2041 \sin 2\,\text{☾} + 0''{\cdot}0677 \sin(\text{☾} - \varpi') - 1''{\cdot}2692 \sin 2\odot + 0''{\cdot}1277 \sin(\odot - \varpi) - 0''{\cdot}0213 \sin(\odot + \varpi).$$

$$\Delta\epsilon = +9''{\cdot}2235 \cos \text{☊} - 0''{\cdot}0897 \cos 2\,\text{☊} + 0''{\cdot}0886 \cos 2\,\text{☾} + 0''{\cdot}5508 \times \cos 2\odot + 0''{\cdot}0093 \cos(\odot + \varpi),$$

in which expressions ☊ denotes the longitude of the moon's ascending node, ☾ the longitude of the moon, ☉ the longitude of the sun, ϖ, the longitude of the perihelion of the earth's orbit, and ϖ', the longitude of the moon's perigee.

It thus appears that by far the largest part of the effect of the nutation arises from the moon, and depends not upon the place of the planet, but upon that of its node. This node [MOON] performs a complete regressive revolution in about eighteen years and a half, in which time the main effect of nutation goes through all its changes. Bradley, the discoverer of the nutation, found out and assigned the law of its largest term; the remaining ones are due to the theory of gravitation. It took him twenty years of observation, somewhat more than the whole period of the change, to detect the law of the anomaly whose existence he became sensible of immediately after his discovery of aberration had cleared away the largest part of the then unexplained motions of the stars. The discovery was completed and published at

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* It will perhaps be more intelligible to imagine all the stars moving slowly forwards in parallels to the ecliptic, the equinox remaining unchanged.

the end of 1747. In 1749 appeared the 'Recherches sur la Precession,' &c. of D'Alembert, in which the phenomenon was shown to be the necessary consequence of the moon's attraction upon the earth. Newton had already, in the 'Principia,' given the general explanation of the subject, and had even foretold, without assigning magnitudes, the existence of those terms of nutation which depend upon twice the true longitudes of the sun and moon; but the most important terms, those depending on the moon's node, appear to have been altogether unsuspected by him.

We now come to such a physical explanation of the cause of precession and nutation as can be given without mathematical analysis. On looking at the motion of the equator arising from precession and nutation, we see that it precisely resembles in character some of the alterations which take place in a planet's orbit, the precession answering to the regression of the nodes, the equation of the equinoxes to the variation of that regression, and the remaining part of the nutation, or the variation of the obliquity, to the variation of the inclination to the ecliptic. It was soon seen by Newton, that on the supposition of the mutual attraction of all the particles of matter, the action of the heavenly bodies on the protuberant parts of the earth must produce exactly that sort of effect on the motion of the equator which the disturbing force of the sun, for instance, produces on the moon. He thus explains, firstly, the precession; secondly, that part of the nutation of the inclination which depends upon twice the longitude of the disturbing body. This explanation (prop. 66, corollaries 18-22) is substantially as follows:—

If a sphere in rotation be attracted by another body, the axis of rotation must remain unaltered: for since a plane drawn through any attracting point and the centre of the attracted sphere cuts the sphere into two perfectly similar halves, there is no effect upon the rotation (or tendency to an effect) arising from the attraction upon one half of the sphere which is not destroyed by the tendency to the exactly opposite effect arising from the attraction upon the other half. If then the earth were a perfect sphere, whatever motion of translation the whole sphere might receive, the axis would always remain parallel to its first position, and there would be neither precession nor nutation. Again, let the earth be a solid of revolution, protuberant for example at the equator, as is the case, and let an attracting point be situated in the plane of the equator; the symmetry just alluded to still exists, and the result is the same. But if an attracting point be not situated in the plane of the equator, the plane passing through the attracting point and the centre divides the spheroid into parts which, though equal, are no longer similarly situated with respect to the attracting point. The alteration of the axis which would take place if one half only were attracted, is no longer counterbalanced by the attraction on the other half: the direction of the axis is therefore continually changed.

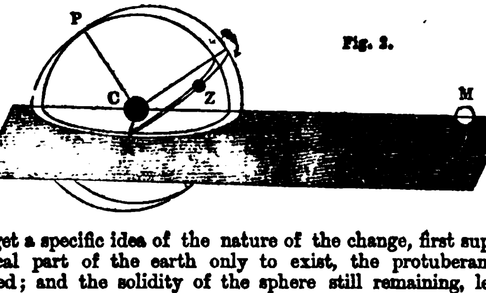

Fig. 2.

To get a specific idea of the nature of the change, first suppose the spherical part of the earth only to exist, the protuberance being removed; and the solidity of the sphere still remaining, let all its matter be supposed to be removed to the centre at C (*Fig.* 2). The diagram shows the spheroid of the earth, distinguishing the inscribed sphere from the protuberant part; the solidity of both parts is supposed to remain, but the matter of the internal sphere is removed to C, that of the protuberant part is not yet introduced: M is the attracting body, and the plane of its orbit is given, while the directions of the earth's rotation and of M's orbital motion are denoted by arrows. At present M produces no effect on the rotation; now let a small mass of matter be affixed to the equator at Z, which will therefore move round the mass C in and with the equator. The consequence will be [GRAVITATION], that the node of this orbit (the equinox A) will regress, or move in the direction opposite to that of the arrows, while the inclination of the orbit will alternately increase and diminish, being greatest when the line CM passes through one of the equinoxes. If we put such satellites all round the equator, the effect will not be altered in quality, but increased in magnitude; and if we fill up all the protuberant part of the spheroid, the effect will still be of the same sort, though further increased in magnitude. The effect of the parts of the protuberance nearer to the pole is, for a given mass, less than that of the parts near the equator. Finally, if we restore the mass of the internal sphere to its proper place, the effect will be less than before; for since no motion of the protuberant part can take place without one of the whole sphere, and since rotation is more difficult to produce, the greater the distance of the masses moved from the axis, the distribution of the mass at C over all parts of the sphere will render M less efficient in the alteration of the direction of the axis. Thus it appears that the phenomena of precession and nutation *may* arise from the consideration of the protuberant part of the spheroid as a fixed satellite to the internal part; but the proof that the precession and nutation *do* so arise consists in taking a strict mathematical process, investigating the precession and nutation in quantity as well as quality, and showing that the results agree with those of observation.

But, as before noticed, the largest part of the nutation depends, not on the place of the moon in its orbit, but on the position of the orbit, that is, on the node of the orbit. Supposing the moon's orbit circular, imagine the mass of the moon to be distributed in a ring all round its orbit. If this ring were simply to revolve in its own plane, the precession and nutation produced by it in the earth, though materially altered in quantity, would be of the same sort as before, and in both cases very small. But suppose the ring to shift its position, as does the moon's orbit, its nodes slowly regressing at the rate of a revolution in eighteen years. This shifting of the position of the ring will of course produce an alteration in the phenomena, and the substitution of the moon revolving in a shifting orbit in place of this ring must now be made. That the effect of the change of the orbit should be greater than that of the planet itself in a fixed orbit ought not to be surprising, since there is no *à priori* reason why it should be either greater or less.

Throughout the solar system there is no action of one planet upon a second, without a corresponding action of the second upon the first. The protuberance of the earth, by which the planets produce precession and nutation, attracts those planets, and slightly varies their motion. In the case of the moon, sensible irregularities, both in longitude and latitude, amounting at the maximum to about 7" in each, were found by Mayer, before Laplace showed them to be the consequences of the earth's protuberance. These inequalities may be made the means of calculating the amount of that protuberance, or, as it is technically called, the ellipticity of the earth: and it is a fact not a little remarkable, that the amount of this ellipticity, as calculated from its effect upon the moon's longitude, agrees with the same, as calculated from its latitude, better than actual measurements of the earth generally agree with one another, while both agree very nearly with the best of the latter. This sort of result had been anticipated as to quality by Newton, who showed that the motion of the equinoxes, being retrograde, proves the earth to be protuberant at the *equator*, and that if it had been protuberant at the *poles* (as many then thought was the case), the precession would have been in the contrary direction.

PRECIPITATE. A name given in chemistry to any comparatively insoluble solid or liquid matter separated from a liquid by chemical action. It is also, though more rarely, applied to solid or liquid matter deposited from a gas; thus snow and rain may be termed precipitates from the atmosphere.

PREDESTINATION. [ELECTION; FREE-WILL; and CALVIN, in BIOG. DIV.]

PREDICABLES. The term predicable (*κατηγορικόν, prædicabile*) is applied in logic to general names, considered as capable of being the predicates of propositions. (On Predication, see ORGANON.] The classes of predicables usually recognised by logicians are five, namely, 1, Genus; 2, Species; 3, Differentia; 4, Proprium; 5, Accidens, which Latin names are translated from the Greek, 1, *γένος*; 2, *εἶδος*; 3, *διαφορά*; 4, *ἴδιον*; 5, *συμβεβηκός*.

The five-fold classification of the predicables does not occur in Aristotle's 'Organon,' nor in any other of his extant writings; and it probably did not occur in any of his lost writings. The word *γένος* is often used by Aristotle to signify a class: and the word *εἶδος* in the sense of a logical species. The word *συμβεβηκὸς* (or *κατὰ συμβεβηκὸς*) is often used by Aristotle to signify that which is contingent or accidental, in opposition to that which is necessary (*ἀναγκαῖον*).

The earliest work in which the received classification of the predicables occurs, is an Introduction to Aristotle's Categories, written by Porphyry of Tyre, the well-known heathen philosopher of the 3rd century (born 233 A.D.) and the author of other extant works. (Printed in Bekker's Aristotle, vol. iv., p. 1–6). Porphyry states, at the outset of this treatise, that a knowledge of the five predicables is necessary for the proper explanation of Aristotle's work on the categories; and he therefore addresses to a certain Chrysaorius a popular account of them, derived from the ancient philosophers, especially the Peripatetics. The five predicables (*αἱ πέντε φωναί*, as they were originally styled) are not however mentioned in Aristotle's work on the categories, as is incorrectly stated in Hermeias, ib., p. 10, b. 14; and it is probable that the "ancient philosophers" alluded to by Porphyry were of considerably later date than Aristotle. An abridgment of Porphyry's treatise on the predicables, by Michael Psellus, of Constantinople, who lived in the 11th century, has also been preserved; and it is reprinted in the beginning of the small Oxford edition of 'Excerpts from Aristotle's Organon' (Clarendon press, 1802).

From this treatise of Porphyry the classification and explanation of the predicables have passed into the various treatises of the Aristotelian logic, and have been repeated in them with some variations and developments, but with little substantial change up to the present day (Whately's 'Logic,' part i.)

The explanation of the predicables which is usually given in treatises on logic is somewhat infected with realism; that is to say, it implies that there is something in nature, besides individual things, corresponding with general notions. On this point see Mansel's 'Aldrich' (§ 5 and Appendix A). Or if not, the least that can be said is that these definitions have an extralogical relation to metaphysics.

The name of any proposed class may be called the *species;* for example, man.

The name of any class including this class is called a *genus,* with reference to the species; for example, animal, with reference to man.

Differentia is the name of any attribute which belongs universally to the species, and to it alone *in the genus.* For example, the power of ameliorating his condition in successive generations, and the power of using language, as belonging to man. A logical *definition* is composed of the *genus* and the *differentia;* thus, according to the explanation of differentia which has been just given, man would be defined logically by saying that he is "an animal which possesses the power of using language."

Proprium is the name of any attribute which belongs to the species, and to it alone. For example the power of speech, as belonging to man.

Accidens is the name of any attribute which may or may not belong to any individual of the species. For example, the colour of the skin in man.

We might fill columns with the views which have been taken of the *proprium* and *accidens.*

We now proceed to consider the predicables, or substitutes for the predicables, which enter into a purely logical system in which contrary terms are admitted. [LOGIC, col. 354.] The predicables which Aristotle really uses are *genus, species,* and *accident:* and as names of class, the genus and species have *terminal precision.* The genus is more than the species; the species less than the genus. The *accident,* which belongs to some but not to all, has a definition which made Aristotle confess that the species is an accident of the genus; distinguished of course from some other accidents by having no exience; that is, by not being the accident of anything external to the genus. According to Aristotle's use of the words genus and species, a species as large as the genus does not exist. We have allowed the term *species* to be used where the genus has but one species: and we must accordingly use other terms. Again, the really metaphysical character of the old terms can only be represented in our system by referring the predicables to the logico-*metaphysical* side of logic. Consequently, our predicables must be the metaphysical notions attached to the relations of terminal precision. [LOGIC, col. 350.] Though obliged to abandon the words *genus* and *species,* we find use for the adjectives *generic* and *specific,* which have parted from their substantives in common language quite enough to justify the use we make of them.

Let a predicated attribute, considered with reference to a class or to another attribute, be *inherent* when the predicate always belongs to the subject; *excludent,* when it never belongs to the subject; *accident* and *non-accident,* when it belongs to part of the subject, and not to the rest. When contrary terms are introduced, the definition of *accident* is also that of *non-accident:* either is the other, by mere force of definition. The *inherent,* the *excludent,* and the *accident* (*non-accident*), are then the three predicables. Each of these predicables may be either *universal, generic,* or *specific.*

A predicable is *universal,* with reference to the term of which it is predicated, when it belongs, in the same sense, to both the classes into which the term divides the *universe.* Thus in the universe *animal,* divided into *man* and *brute, life* is a universal *inherent,* inherent both of man and brute: *mineral* is a universal excludent, both of man and brute; *strength* is a universal accident and non-accident, belonging to some both of men and brutes, and not to the rest. The universal predicables create no distinction, and are therefore of little or no logical force.

A predicable is *generic* when its quantity of application is augmented by taking in the additional extent of some larger genus, in which the term predicated of is a species: *specific,* when this is not the case. Thus, *lawyer* is a *specific accident* of man; *accident,* some are and some not; *specific,* any larger genus of animal which contains man has no *lawyer* in the additional extent. For these reasons it is also a *generic* non-accident. The following table will now be easily collected; and the reader of the article LOGIC will see that, just as the words *subidentical, superidentical,* &c., might be dispensed with, since *deficient species, exient genus,* &c., might supply their places, so the extended system of predicables might be replaced in terminology by one derived from compounding the metaphysical relations of terminal ambiguity. The symbols are here read forwards:—

<table>
<tr><td>)o)</td><td>Inessential Dependent</td><td>Specific Accident
Generic Non-accident</td></tr>
<tr><td>| |</td><td>Dependent Essential</td><td>Specific Inherent</td></tr>
<tr><td>(o(</td><td>Independent Essential</td><td>Generic Inherent</td></tr>
<tr><td>)o(</td><td>Inalternative Repugnant</td><td>Generic Excludent</td></tr>
<tr><td>| · |</td><td>Repugnant Alternative</td><td>Specific Excludent</td></tr>
<tr><td>(o)</td><td>Irrepugnant Alternative</td><td>Generic Accident
Specific Non-accident</td></tr>
</table>

The old predicables, taken together, do not constitute a *logical* list of predicates. Their companions, the CATEGORIES, are now almost universally declared to be metaphysical, not logical. Sir W. Hamilton, in the recently published 'Lectures[*] on Logic,' does not mention the word *predicable:* at least it is not in the index, and we cannot find it in the proper places of the work.

PREDICAMENTS. The Latin term for the CATEGORIES.

PREDICATE. [ORGANON.]

PREFIX. [LANGUAGE.]

PRELATE (etymologically from *præ* and *latus*), a person *preferred* or advanced before another; but it is confined to a particular species of preferment or advancement, namely, that amongst the clergy, and it is applied to those only among them who have attained the very highest dignity, that of bishop or archbishop, to which we may add patriarch, in such churches as have an officer so denominated. The word prelate has, however, in ancient times been applied to simple priests members of the clerical body in general.

PRELUDE (*Præludium,* a preamble), a brief introduction to a piece of (most commonly) pianoforte music; a few chords or a flourish, to prepare the hand of the player, and draw the attention of the auditors to what is to follow. A prelude is, or is supposed to be, an extemporaneous effusion, and as such is no bad test of the musical knowledge of the performer.

PREMISES. [ORGANON.]

PREMIUM (in the sense in which it is used in the article BOUNTY) is a reward given out of the public revenue to encourage manufactures or other branches of industry; but prizes given by agricultural and other societies are in reality the same thing as premiums. Premiums encourage and reward competition; but when it is proposed to foster any new art by liberal premiums, there is less certainty of an interest thus sustained establishing itself upon the only natural foundation—that which arises from the encouragement of the public; and premiums then fall under the same objections as bounties. These objections are inseparable from a system of bounties, but the judicious distribution of premiums may occasionally be attended with advantage. Adam Smith says of premiums that, "by encouraging extraordinary dexterity and ingenuity, they serve to keep up the emulation of the workmen actually employed in those respective occupations, and are not considerable enough to turn towards any one of them a greater share of the capital of the country than what would go to it of its own accord." A patent is a sort of premium for the encouragement of useful inventions; but the giving of money to support an otherwise unprofitable manufacture must be injurious to the community.

PREMONSTRATENSIAN ORDER. [AUGUSTINE, CANONS OF THE ORDER OF.]

PREPOSITIONS are certain words which express a relation between different things. All words may be divided into notional and relational. [NOTION, NOTIONAL.] Notional words are those which express notions, and which are objects of the understanding. Relational words are those which merely express a relation between the different things which are expressed by notional words. Thus, in "he went *to* town," "he walked *with* his friend," the words *to* and *with* are relational words; that is, they connect the notions of "he went" and "he walked" respectively with the notions of "town" and "friend."

Prepositions are so called because they are *preposed* or prefixed to the words with which they are connected; but the name is an unfortunate one, since they are sometimes *postponed* or placed after such words, as in *wherewith, wherein, wherefrom, thereby,* &c. In languages like our own, which have hardly any inflections, the relation which one thing bears to another can only be expressed by means of prepositions; but in languages which possess inflections, like the Latin and Greek, the same relation may frequently be expressed by means of cases, which are in fact prepositions placed at the end of nouns. Thus, in the expression "the son *of* the king," we express the relation between "son" and "king" by the preposition "of"; while in Latin the same relation is expressed by *is* placed after the Latin word for king, *filius reg-is.* But as the meaning of these case-endings was not always definite enough, it became customary to mark the relation more precisely by prefixing certain words, as in our own language. The case-endings however were not dropped; so that in such expressions as *ad urb-em, cum reg-e, pro reg-e,* the noun may be said to have two words to mark relation, one placed before and the other after it.

The number of prepositions differs, as might be expected, in different languages. The Greek grammarians admit only eighteen, the Latin about fifty. In English, the following words are usually considered as prepositions:—Above; about; after; against; among, amongst; amid, amidst; around, round; at; between, betwixt; beyond; before; behind; beneath; below; beside; by; down; for; from; in, into; near, nigh; of; off; over; on, upon; since; through, throughout; till, until; to, unto; toward, towards; under, underneath; up; with; within; without.

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[*] These lectures were published a few days after our article on LOGIC: edited by Mr. Mansel and Mr. Veitch. They fully confirm, to our minds, all that we said both for and against Sir W. Hamilton. Our idea of his power over everything but quantity is enhanced: and so is our opinion of his utter incapacity in all that is mathematical in notion. The editors have faithfully preserved to us the means of judging of this difference. We hold these lectures to be the greatest of Hamilton's works: they were substantially written when he was first appointed to his chair; and so much do they preserve their primitive character, that, though read year after year for twenty years, the lecturer always read, in lecture 3, the following words: "I would interpolate some observations which I ought in my last lecture to have made . . . ." There is, accordingly, a freshness about the style which is truly pleasing; and the worst we have to say about the non-quantitative portions is, that Hamilton has frequently supplied, by translation from Krug and Esser, what he would have done much better with his own pen. His own system does not form a part of the lectures; and the scraps which the editors have been able to find do not add anything material to what was known of it before.

Besides these prepositions, there are in English, Latin, Greek, and many other languages, certain particles never found singly, or uncompounded, and which are therefore called inseparable prepositions, as, in English, *be*, *for*, *fore*, *mis*, &c., which occur in such words as *be-stir*, *be-speak*; *for-bid*, *for-sake*; *fore-see*, *fore-know*; *mis-take*, *mis-deed*, &c.

PREROGATIVE, a word descended to us from the times of the Romans, or, rather, adopted from their language, to denote a certain power in the constitution of monarchical states. Its etymology is obvious, though the formation is not perhaps quite accordant with the analogies. *Præ* and *rogo* would seem to give the sense of precedence in asking, while prerogative means precedence in being asked, the right of having the consent first obtained of the party in whom the prerogative is vested, before any change shall be made in the matters comprehended within the prerogative. The term is confined to cases of dignity, to things indeed which affect the common interest when men are bound together in a political state; and though we might speak, as indeed men sometimes do, of the prerogative of the House of Lords, or the prerogative of the House of Commons, or even of the prerogative of the people, it is more usual to regard the word as belonging to the right which the crown possesses of being consulted, and its consent obtained, in whatever concerns the business of the nation.

Thus the consent of the sovereign must be first obtained before any new law can be made, or any change effected in the existing laws; and this appears to be prerogative in its purest state, and, indeed, in its only state of absolute purity. Other things which are now understood to be comprehended under the term prerogative, are only accretions to this the true prerogative, or things which have naturally shot forth out of it: unless we choose to take a view of the whole subject which shall take it wholly out of the scope of the etymological sense, and regard, as indeed many do, the word prerogative as standing to indicate the primordial and original power of any prince, the king of England for instance, which has been from time to time reduced and confined by the resistance, passive or active, of the subject. However the term may be chosen or applied, it now denotes not only the privilege of being consulted in any intended change of the law, and the consent obtained, but the right of making war or peace, of laying embargos, of commissioning officers in the army and navy, of sending and receiving ambassadors, of making treaties, of bestowing honours, conferring rank, and creating peers. To these are to be added the pardoning of offenders, which is sometimes called the prerogative of mercy; the calling, proroguing, and dissolving parliament, in which however the prerogative has been restrained by positive enactments; and, lastly, various rights which the sovereign enjoys as head of the church. All these things the crown does by its prerogative, without any application to parliament, or to any court or council whatever, though members of the Privy Council, those particularly who form what is called the Cabinet Council, or the ministers, are supposed to advise the sovereign in the exercise of the prerogative, and are sometimes made answerable by parliament for the injudicious or dangerous exercise of it. Theoretically however and nominally, these are prerogatives of the sovereign himself—rights inherent in him in virtue of his office, as much his as the subject has certain rights belonging to him, either as a member of the great community of Englishmen, or as belonging to some particular section to which he belongs, or to some particular office in which he is placed. In the mutual respect of each, and the forbearance of each to encroach on the rights or prerogatives belonging to each other, lies the balance of the English constitution; and out of it arises security to all, and the enjoyment of the blessings which belong to a well-ordered political community. When evils are perceived, when the subject claims rights which are incompatible with wholesome government, or when the crown claims rights as falling within the scope of any part of the prerogative which are opposed to the common good, there are remedial powers in the constitution which bring things right; and it is one of the most important functions of the two houses of parliament to see to this.

PREROGATIVE COURT, a court formerly held by each of the archbishops (or their officials) of England and Ireland. This court was held by virtue of the prerogative, for the purpose of trying the validity of wills, registering them, and granting probate or administration (and hence its title), which attached where one died possessed of bona notabilia, that is, of goods to the value of 5*l.* (except in the diocese of London, where it is 10*l.*) in one diocese or peculiar, and also goods, altogether of the same amount, in some other diocese or dioceses, peculiar or peculiars, within the same province—or where one, not being on a journey, died in one diocese or peculiar, possessed of goods of that amount in another diocese within the same province. One administration thus became sufficient; and the inconvenience and uncertainty of taking out administration in various dioceses, &c., were avoided. This court ceased to exist on the transference of the jurisdiction of the spiritual courts, in matters testamentary, to the crown by statute 20 & 21 Vict. c. 77.

PRESBYTERIANS (πρεσβύτερος, an elder) are professors of the Christian religion who believe that there is no order in the Church, as established by Christ and his Apostles, superior to that of Presbyters; that all ministers, being ambassadors of Christ, are equal by commission; that Presbyter or Elder, and Bishop, are only different names for the same person; and that Deacons are laymen whose office is chiefly to take care of the poor. A Presbytery (πρεσβυτέριον) they regard as a society of clerical and lay Presbyters, or, as they usually call them, Ministers and lay Elders. In support of these opinions they allege several passages of the New Testament. They affirm that the primitive form of church government was universally Presbyterian, and that this form, having, after the time of the Apostles, been supplanted by Episcopacy, was restored in some parts of Europe after the Reformation had begun.

The most noted Presbyterian Church of the present day is that of Scotland, called the Kirk. Presbyterianism was introduced into Scotland about 1560. Under Calvin's direction this discipline had already been put into operation at Geneva, whence it was brought by John Knox into his native land. King James I., who had been a Presbyterian in Scotland, and who embraced Episcopacy upon coming to the English throne, made Episcopacy, nominally at least, the religion of Scotland. In the reign of Charles I., Presbyterianism regained the ascendancy, but Episcopacy was once more declared the established religion at the restoration of Charles II. At the Revolution in 1688, Presbyterianism was re-established in Scotland by authority of Parliament, and thus it has continued to the present time.

The constitution of Presbyterianism in the established Church of Scotland is as follows:—The Kirk Session, consisting of the minister and lay or ruling elders of a parish or congregation, is the lowest court of judicature, the minister being, ex officio, the moderator or chairman. The Presbytery is next in authority, and consists of all the ministers of a certain district, and one ruling elder from each parish, who is chosen half-yearly. At the meeting of a Presbytery, a moderator is chosen out of the ministers. There are 84 Presbyteries, each consisting of parishes varying in number from 3 to 32. The Provincial Synods, of which there are 16, meet twice in the year, and are composed of the Presbyteries within the provinces which give name to the Synods. The highest authority is the General Assembly, which meets annually. [General Assembly of the Church of Scotland.] Persons are appointed ministers by the laying on of the hands of the Presbytery. The maintenance of the clergy is regulated by the state, and they are nominated to livings by patrons. The Kirk has no Liturgy, no altar, and no instrumental music. Its doctrine is Calvinistic. At the Revolution the Westminster Confession was appointed the standard of the national faith, and it was enacted that no person should be admitted or continued a minister or preacher in this church, without subscribing to this Confession of Faith as his faith. By the Act of Union in 1707, the same subscription was required of all professors, principals, regents, masters, and others bearing office in any of the four universities of Scotland; but this has been repealed.

There are however many Presbyterians in Scotland who do not belong to the national establishment, although they maintain the same articles of faith as the members of the Kirk. [Dissenters.] The most important is the Free Church, which separated from the establishment in 1843, on a question of church patronage. [Free Church of Scotland.] The other sects (United Presbyterians, Reformed Presbyterians, Original Seceders, &c.) also preserve similar forms, and the differences between them chiefly relate to the question of national religious covenanting. [Cameron, Richard, in Biog. Div.; United Presbyterian Church.]

The first Presbyterian congregation in England was formed at Wandsworth, near London, in 1572. In the reign of Charles I., 1645, it was proposed, in the treaty of Uxbridge, to make the Established Church of England Presbyterian, and the proposition was carried into effect by way of trial in 1646. In 1649 the Presbyterian discipline was sanctioned by parliament, and the Established church was Presbyterian till Episcopacy was restored with the restoration of Charles II. in 1660. [Nonconformity.] The successors of the old Presbyterian congregations in England have in general become either Unitarians or Independents: the congregations which are at the present day adherents of the Presbyterian form of church government belong to, or maintain friendly relations with, the Presbyterian churches of Scotland. The Synod of English Presbyterians, a separate organisation holding the principles of the Free Church of Scotland, is composed of about 100 congregations, forming 7 presbyteries; there are about 70 United Presbyterian congregations in England; and there are 3 presbyteries, comprising 17 congregations, which profess the principles of the Established Church of Scotland. In the north of Ireland, Presbyterianism is the prevailing faith, and there it is regularly constituted, though Episcopacy is the form of the Established Church. In the British Ccolonies there are numerous congregations of Presbyterians. The Presbyterians of the United States of America number about 6000 congregations.

PRESCRIPTION. "No custom is to be allowed, but such custom as hath been used by title of prescription, that is to say, from time out of mind. But divers opinions have been of time out of mind, &c and of title of prescription, which is all one in the law." (Litt., § 170.) According to this passage, "time out of mind," and "prescription," which are the same thing in law, are essential to custom: another essential to custom is usage. But there is a claim or title which is specially called prescription, and which is like custom so far as it has the inseparable incidents of time and usage; but it differs from custom in the manner in which it is pleaded, which difference shows the difference of the right. This claim is called prescription, because the plaintiff or defendant who makes it "prescribeth that," &c.; stating, after the word "prescribeth," the nature of his claim.

The following is an example of a prescription (Co. Litt., 114, a):—"I. S., seised of the manor of D. in fee, prescribeth thus: that I. S., his ancestors, and all whose estate he hath in the sayd manor, had and used to have common of pasture time out of mind in such a place, &c., being the land of some other, &c., as pertaining to the same manor." The claim of a copyholder of a manor for common of pasture in the manor, alleges a custom time out of mind within the same manor, by which all the copyholders of the manor have had and used common of pasture in it. The claim by prescription, then, is properly a claim of a determinate person: the claim by custom, as opposed to prescription, is local, and applies to a certain place, and to many persons, and perhaps, it may be added, to an indeterminate number, as the inhabitants of a parish. The following definition of prescription appears to be both sufficiently comprehensive and exact:—"Prescription is when a man claimeth anything for that he, his ancestors, or predecessors, or they whose estate he hath, have had or used anything all the time whereof no memory is to the contrary." (T. de la Ley.) From this definition it follows that prescription may be a claim of a person as the heir of his ancestors, or by a corporation as representing their predecessors, or by a person who holds an office or place in which there is perpetual succession; or by a man in right of an estate which he holds. It is said that certain persons, attorneys for instance, may prescribe that they and all attorneys of the same court have certain privileges; it seems indifferent whether this is called prescription or custom, but it is more consistent with the old definitions to call it prescription, since it is not a local usage, and it is by or on behalf of a determinate number of persons, that is, all the attorneys of a particular court. It is also said that parishioners may prescribe in a matter of easement, as a way to a churchyard, but not for a profit out of land: such a prescription, however, is not contained within the above definition, and is in all respects more properly a custom.

It is essential to prescription (subject to the limitations hereinafter mentioned) that the usage of the thing claimed should have been time out of mind, continuous, and peaceable. "Time out of mind" means, that there must be no evidence of non-usage or of interruption inconsistent with the claim and of a date subsequent to the first year of Richard I., which is the time of the commencement of legal memory. If it can be shown, either by evidence of persons living, by record, or writing, or by any other admissible evidence, that the alleged usage began since the first of Richard I., the prescription cannot be maintained. Repeated usage also must be proved in order to support the prescription, but an uninterrupted enjoyment for twenty years has been considered sufficient proof, where there is no evidence to show the commencement of the enjoyment. [PRESUMPTION.]

The thing prescribed for must be something definite. It must also be reasonable; and it must not be inconsistent with any established principle of law; for instance, it is said that a sheriff cannot prescribe for taking gifts for doing the duties of his office. It follows generally, that there can be no prescription to do any wrong or commit nuisance, or for a thing contrary to a statute. No prescription is good which is against the king's right (subject to the limitations hereafter mentioned), conformably to the maxim, Nullum tempus occurrit regi; yet a grant from the crown may be presumed.

Where a man prescribes for a thing which cannot be granted or aliened without deed, he must prescribe in himself, and in his ancestors, whose heir he is; and he cannot prescribe in himself and those whose estate he hath; for he cannot have their estate without deed or other writing which ought to be showed to the court. But of things appendant to a manor or to other lands or tenements, a man may prescribe that he and they whose estate he hath, have been seised of those things as appendant to the manor or to such lands and tenements time out of mind of man. And the reason is, that such manor or lands and tenements may pass by alienation without deed. (Litt. § 183.)

From the nature of the claim of prescription, it follows that a man cannot make a title to land by prescription, for the evidence of a title to land is quite different from and inconsistent with that of a thing claimed by prescription, which only applies to incorporeal things. A man may prescribe for all franchises and privileges which he may have, without a title appearing on record, as for waifs, estrays, wreck, treasure trove; and to have a park or warren, to have a fair, market, or right to toll, &c.

Nothing can be prescribed for at the present day that may not be the subject of grant; for the allegation of usage time out of mind must be usage of something which could originate in a lawful way. When, then, the claim of prescription is allowed, it is equivalent to admitting that there was an original grant which is now lost. (Luttrel's case, 4 'Rep.' 86.) It is however no proof of a grant.

A question has been raised whether the same thing may be claimed by prescription and by custom, which is nearly the same thing as saying, whether the same thing could be granted to all the inhabitants of a given place, and also granted to one person in that place, either in gross or in respect of a piece of land; as for instance, whether a private right of way may not exist together with a public right of road. (Blewett *v.* Tregonning, 3 A. & E. 586.) If *all* prescription supposes an original grant, it is an inconsistency to suppose a grant to A. and a grant of the same thing to A. and others with him.

There is some confusion in the books as to prescription and custom, and the real distinction between them has perhaps not always been observed. It seems immaterial whether the thing whose origin is unknown is called prescription or custom, for the two incidents of time and usage belong to both. Still there is the distinction as to the persons who claim, which has been already stated; and there is of course a difference in the evidence, which results from the difference in the persons claiming, or in whose right it is claimed.

A prescription may be lost or destroyed in various ways. If the thing in respect of which the prescription is claimed is destroyed, the prescription also is destroyed. A franchise by prescription is destroyed if the same liberties are granted by the king by charter. It may be lost by non-usage. But a prescription is not lost by changes which are immaterial and do not affect the nature of the claim: thus if a man prescribes for a watercourse to a fulling-mill, and he converts it into a grist-mill, he does not lose his right, which is generally to have a watercourse to a mill on a given site. And if a corporation should prescribe, and afterwards have a new name, it would not lose the right. (4 'Rep.,' 86.) When the ownership of the land and of the thing claimed out of or upon it are united in the same person, the prescription is destroyed.

Recent Acts have made some alterations as to prescription, and limited the time within which actions can be brought or suits instituted relating to real property. The 3 & 4 Will. IV. c. 27, applies to everything of a corporeal nature, which is land in the sense in which land is interpreted in that Act; but it only applies to those kinds of property of an incorporeal nature, which are advowsons, annuities, and rents. The 2 & 3 Will. IV. c. 100, applies only to cases of modus and exemption from tithes. The 2 & 3 Will. IV. c. 71, which is entitled "An Act for Shortening the Time of Prescription in certain cases," applies (§ 1) to "claims which may be lawfully made at the common law by custom, prescription, or grant to any right of common or other profit or benefit to be taken from or upon any land, &c., except such matters and things as are therein specially provided for, and except tithes, rents, and services;" (§ 2) "to any way, or other easement, or to any watercourse, or the use of any water," &c.; and (§ 3) to the use of light. No claim to the things comprised within this statute "shall, when such right, profit, or benefit (as is mentioned in § 1) shall have been actually taken and enjoyed by any person claiming right thereto, without interruption for the full period of thirty years, be defeated or destroyed by showing only that such right, profit, or benefit was first taken or enjoyed at any time prior to such period of thirty years; but nevertheless such claim may be defeated in any other way by which the same is now liable to be defeated; and where such right, profit, or benefit shall have been so taken and enjoyed as aforesaid, for the full period of sixty years, the right thereto shall be deemed absolute and indefeasible, unless it shall appear that the same was taken and enjoyed by some consent or agreement expressly made or given for that purpose by deed or writing." As to the rights enumerated in the second section, the terms of twenty and forty years are respectively fixed in the place of the terms of thirty and sixty years mentioned in the first section. Under the third section, which applies to lights, an absolute right to light may be acquired by twenty years' uninterrupted enjoyment, unless the use has been enjoyed by some consent or agreement made or given by deed or in writing. The eighth section provides "that when any land or water upon, over, or from which any such way or other convenient watercourse or use of water shall have been enjoyed or derived, hath been or shall be held under any term of life, or any term of years exceeding three years from the granting thereof, the time of the enjoyment of any such way or other matter as therein last mentioned, during the continuance of such term, shall be excluded in the computation of the said period of forty years, in case the claim shall within three years next after the end or sooner determination of such term be resisted by any person entitled to any reversion expectant on the determination thereof." Formerly it was necessary for all persons who claimed in respect of an estate and had not the fee, to claim in the name of the person who had the fee, but under the last-mentioned Act "it shall be sufficient to allege the enjoyment thereof as of right by the occupiers of the tenement in respect whereof the same is claimed, for such of the periods mentioned in the Act as may be applicable to the case, and without claiming in the name or right of the owner of the fee, as is now usually done."

The statute applies also to "any land or water of the king, his heirs, or successors, or any land being parcel of the duchy of Lancaster or of the duchy of Cornwall."

By the common law a man might prescribe for a right which had at any time been enjoyed by his ancestors or predecessors; but the statute of 32 Hen. VIII. c. 2, enacted that no person should "make any prescription by the seisin or possession of his ancestor, unless such seisin or possession hath been within threescore years next before such prescription made." This statute prevented any claim being made by prescription unless there had been seisin or possession within sixty years; but it still allowed the commencement of the enjoyment at any time within legal memory before the sixty years to be proved. The Act, 3 & 4 Will. IV. c. 100, directs that "the respective periods of years thereinbefore mentioned shall be deemed to be the period next before[*] some suit or action wherein the claim or matter to which such period may relate shall be brought into question" (§ 4); but it only excludes proof of commencement of enjoyment, and it only gives the absolute right, when the several periods of years, reckoning backwards from the time of some suit or action wherein the matter is brought in question, are completed; and it neither excludes the proof nor gives the absolute right if there has been an interruption, within the meaning of this statute, which has been submitted to or acquiesced in "for one year after the party interrupted shall have had notice thereof, and of the person making or authorising the same." In these cases, if there has been seisin or possession of the ancestor or predecessor within sixty years, the statute of Henry VIII. will still apply, and evidence of the commencement of enjoyment within legal memory may still be given.

The Acts here enumerated do not apply to a claim "of a manor, a court leet, a liberty, separate jurisdiction, treasure trove, wreck, waifs, and other forfeitures, fair, market, fishery, toll, park, forest, chace, or any privilege legally known as a franchise, as well as anything pertaining to those rights which come under the description of dignities or offices." (Mr. Hewlett's 'Reply, &c., to certain Evidence before the Select Committee of the House of Commons on Records, February, 1836.')

The term prescription is derived from the Roman law, but the meaning of the term in the Roman law is different. Blackstone says (ii, c. 17, note f), "This title of prescription was well known in the Roman law by the name of usucapio ('Dig.,' 41, tit. 3, s. 3), so called because a man that gains a title by prescription may be said *usu rem capere*." This remark is not correct. Usucapio in the Roman law was founded solely on possession as such [Possession], and it applied only to "corporeal things:" "by the laws of the Twelve Tables usucapion of moveable things was complete in one year; and of land and houses in two years." (Gaius, ii. 42.) "To usucapion was afterwards added, as a supplement, the longi temporis præscriptio, that is, an exceptio (plea) against the 'rei vindicatio,' the conditions of which were nearly the same as in the case of usucapion." (Savigny, 'Das Recht des Besitzes,' p. 6.) The term præscriptio was properly applied to that which a plaintiff (actor) prefixed (præscripsit) to the formula by which he made his demand against a defendant, for the purpose of limiting or qualifying his demand. It seems afterwards to have been used as equivalent to exceptio or plea.

Bracton (ii., c. 22) treats of ownership acquired "sine titulo et traditione, et per usucaptionem, s. per longam continuam et pacificam possessionem;" but he adds that no time was legally fixed as necessary to make the title perfect, and it depended on the discretion of the justices. It appears, then, that the rule as to the time of prescription commencing from the 1st of Richard I. (A.D. 1189) was not established at the time when Bracton wrote, which was in the reign of Henry III. Bracton observes that "longa possessio," as above defined by him, "sicut jus parit jus possidendi et tollit actionem vero domino petenti;" or the actual possession gives in course of time the right to possess. [Possession.] In the same chapter he treats of the mode of acquiring "possessio rei incorporalis, sicut possessio juris, viz. alicujus servitutis per patientiam que trahitur ad consensum, et longum usum et pacificum." Bracton then makes no distinction between a thing corporeal and incorporeal as to the mode of acquiring right by possession and long usage, nor does he use the word prescription.

(Comyns, *Prescription:* Viner's *Abridgment;* Starkie, *Law of Evidence;* Blackstone, ii., p. 255, Mr. Kerr's ed.)

PRESCRIPTION has, by the law of Scotland, a much wider operation than either by the civil law or the law of England, supplying the place of the Statute of Limitations in the latter system. It not only protects individuals from adverse proceedings which other parties might have conducted if the lapse of time had not taken place, but it in some instances creates a positive title to property. The prescription by which a right of property can be established is that of forty years—a period borrowed from the *Praescriptio quadraginta annorum* of the Romans. Whatever adverse right is not cut off by the other special prescriptions of shorter periods, is destroyed by the *long* prescription. It may be said generally to preclude the right of exacting performance of any claim, as to which no judicial attempt has been made to exact performance for forty years from the time when it was exigible. To create a title to real property, the long prescription must be both positive and negative. The party holding the property must, by himself or those through whom he holds, have been forty years in unchallenged possession of the property on a title ostensibly valid—this is called positive prescription; and the claimant and those whom he represents must have been forty years without an ostensible title, and must, by not judicially attacking it, have tacitly acquiesced in the possessor's title—this is called negative prescription. An action raised in a competent court interupts the long prescription. It is usually stated in the Scottish law-books that it is interrupted by the minority of any person who could challenge the opposing right; but it would be more correct to apply in this case the phraseology of the French lawyers, who say it suspends prescription, as the years of minority are merely not counted in making up the period of forty years, while, when there is a judicial interruption, a new period of forty years commences to run. When the prescription applies to a pecuniary obligation, payment of interest or an acknowledgment of the obligation will interrupt it.

The other and shorter prescriptions cut off particular descriptions of claims or methods of supporting them. By the vicennial or twenty years' prescription, holograph writings, not attested with the usual solemnities of Scottish writs, cease to "bear faith in judgment." An obligation of cautionary or suretyship is limited to seven years. Bills of exchange and promissory notes cease to have force after six years; but the debts which they represent, if they do represent debts, may be proved by other means. The quinquennial prescription cuts off all right of action, after the lapse of five years, on bargains provable by witnesses. It also protects agricultural tenants from a demand for rent after they have been five years removed from the land to which the demand applies. The triennial, or three years' prescription, is very important. It cuts off claims on account of goods or services, the three years running from the date of the last item of the account; and also claims for wages, each year's wages running a separate prescription, and ceasing to be exigible, if not pursued for, in the lapse of three years from the time when it became due, such claims being then only provable by the writing or oath, that is, admissive on oath of the defendant.

PRESENTATION. [Benefice.]

PRESENTATION TO A LIVING. [Advowson.]

PRESENTMENT. [Jury.]

PRESENTMENT OF A BILL OR NOTE. [Bill of Exchange.]

PRESS, HYDRAULIC. [Hydraulics.]

PRESS, PRINTING. [Printing.]

PRESSURE. To explain the use of this term in mechanics, we must remember its previous and common use. When we attempt to move matter, or when we sustain a weight, the effect is accompanied by a perception which is called *pressure*. The sense of touch is nothing but this perception; contact without pressure is not touch, and there are even weights too small to give the sense of touch. A small feather supported on the open palm is not felt, though it would fall to the ground if the palm were removed.

The word pressure is soon indissolubly connected with the notion of motion caused or prevented. Let the obstacle which is pressed suddenly break, and the hand which pressed must follow, unless the person who presses can take an instantaneous warning to cease his effort. Hence, whenever we see motion caused, prevented, or altered, we are apt to carry with us the notion that pressure is exerted. The weight in the scale of a balance is said to press the scale; not that we suppose the scale to have muscles to be acted upon, and nerves to carry news of the action to a living brain, but that we see a counteraction of the known tendency of the weight to fall, and know that if the counteraction were the work of a human agent, that agent would be conscious of the perception of pressure. Hence everything fitted to produce the sensation of pressure, such as a weight, the elasticity of a spring, &c., comes to be called a pressure, and the word loses its meaning of a perception conveyed, and takes that of an agent proper to produce that perception if the human being were situated so as to receive it.

This consideration is not unimportant, for a latent confusion between pressure as a perception and pressure as a cause proper to produce that perception has prevented many from a clear understanding of the Newtonian doctrine of gravitation, has caused some to reject it altogether, and has made one or two write books against it. We have in mechanics the word Force, which really means nothing but the cause of motion produced, altered, or prevented; but this word force having been used in two distinct senses, namely, both in the sense of pressure and in that of acceleration produced by pressure, it is sometimes necessary to have recourse to the word *pressure* instead of *force* where precision of language is required. The motion of the planets is continually altered: there must be a producing cause of that alteration, a force, an agent proper to produce the sensation of pressure in a human being who should interfere with it, if such a thing could be; or, in common language, a pressure. If it is found that the laws of alteration in a planet's motion are such that the pressure must always be directed towards the sun, and if we thence say that the sun attracts the planet, or pulls the planet towards it (pull and pressure being the same terms, or at least only differing in their original meaning by this, that a pull is made towards the agent, and a pressure from him), a person who thus learns the notion of attraction may, without absolutely attributing consciousness to the sun, obtain a rather mysterious notion of attraction from something remaining of the original sense of the word pull or pressure. This it is of course desirable that he should get rid of; but if, from failing to do so, he should be inclined to doubt of what is called attraction, he would do well to remember that by the same rule he should deny that a weight placed in the scale of a balance presses against the scale, or that a weight hung to a beam pulls the beam.

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[*] Richards *v.* Fry, 7 A. & E. 698.

Having said thus much, nothing remains as to the manner of estimating pressures, except to give a reference to the articles Force, Mass, Momentum, Motion (Laws of), &c.

We thence collect that in problems of dynamics it is requisite to estimate pressure (in cases in which it cannot be balanced against a weight) by the velocity which it would produce or destroy in a given mass of matter, and in a given time: it being known that the weight of a mass means that pressure which, applied to the mass, would produce in one second 32·19 feet of velocity. An instance of this process occurs in Centripetal and Centrifugal Forces.

Pressure can only produce an effect in *time;* an instantaneous alteration of velocity (as noted in Impulse) being mechanically absurd. But if a pressure produce its whole effect in an imperceptible time, there is all the appearance of an instantaneous destruction or creation of velocity. Suppose a hammer, for instance, to strike an anvil with a velocity of 20 feet in a second. The instant the contact begins, both hammer and anvil begin to be compressed, and the compression begins at the rate of 20 feet a second. But the resistance to compression is enormous, and is a pressure which, though it takes time to destroy any velocity, yet will destroy a velocity of 20 feet a second in a very small fraction of a second. The moment the velocity is all destroyed the effort of the anvil and hammer (both of which are compressed) endeavouring to restore themselves, the continuation in fact of the pressure which destroyed the velocity, will give a velocity to the hammer in a contrary direction, or the hammer will rebound, as it is well known to do. In the appendix to Professor Whewell's 'Elementary Treatise on Mechanics' (third or fourth edition), a mathematical investigation of such problems (by Mr. Airy) will be found, upon highly probable hypotheses as to the constitution of matter. The following result of these hypotheses (which cannot be far wrong) will give an idea of the enormous pressures which are created in common cases of what is called *impact:*—If a column of iron three inches high be let fall on an anvil two feet high, from a height of eight feet, the compression of both hammer and anvil is about one-thousandth of a foot, and the pressure exerted at the moment when it is greatest is that of a quiescent column of iron similar to the hammer in its action, but of no less than 4000 feet high.

PRESSURE, CENTRE OF. When a fluid presses upon a surface, there is a point in that surface (known as the *centre of pressure*) at which, if a force be applied in the same line with the pressure of the fluid and equal to the whole of that pressure, but in a contrary direction, it will balance or counteract the whole pressure of the fluid. It is often of great importance to find the centre of pressure, and for the methods of doing so we must refer to Hydrostatics.

PRESUMPTION. A presumption may be defined to be a belief or inference as to the existence of a fact not actually known, arising from its necessary or usual connection with others which are known.

A fact may be proved by the immediate knowledge of the witnesses to it, which is called direct evidence. If it cannot be so proved, some other fact may generally be proved by direct evidence, from which the fact in question may often be inferred. If such other fact can be proved, and the existence of the fact in question can be inferred, such inference is a presumption. The inference may be either strictly logical or necessary, or it may be only probable, that is, the fact inferred may be true or it may not be true. If we cannot infer from the fact proved that the fact in question may be true, there can be no presumption at all as to such last fact. In all cases then, in order to establish a presumption, there must necessarily be an inference from a fact or facts; but the inference may be either necessary or probable. If necessary, it cannot, by the supposition, be disproved; if probable, it may either be disproved by evidence, or it may not be possible to disprove it for want of evidence, and yet the inference will still only be probable.

Presumptions which are necessary can hardly ever be considered as otherwise than conclusive in any system of law. Presumptions which are probable only may, by positive law, be made as conclusive as necessary presumptions, that is, it may not be permitted to disprove them when they could be disproved; or where such disproving evidence is wanted, and yet the inference is only probable, positive law may give it the same conclusive force as a necessary presumption.

A presumption, when established, that is, a fact when presumed, is legally the same as a fact proved in such manner as the particular system of law requires such fact to be proved. If then the law annexes any legal consequences to a given fact when proved, it annexes the same to it when the fact is legally presumed. It is only by virtue of legal consequences being annexed to facts that they become objects of jurisprudence. The establishment then of a presumption, in a legal sense, is only the establishment of a fact to which certain legal consequences are annexed.

In our own system, the presumption is sometimes made by a judge or a number of judges, and sometimes by a jury, but the consequences are the same. Some writers say that presumptions are either "legal and artificial" or "natural." They divide "artificial or legal presumptions" into two kinds, immediate and mediate. "Immediate are those which are made by the law itself directly and without the aid of a jury. Mediate presumptions are those which cannot be made but by the aid of a jury." Presumptions may therefore be divided into three classes: 1, Legal presumptions made by the law itself, or presumptions of law; 2, Legal presumptions to be made by a jury, or presumptions of law and fact; 3, Mere natural presumptions, or presumptions of fact."

The first class of presumptions, it is said, are either absolute and conclusive, or they may be rebutted by evidence to the contrary. The presumption of law that a bond was executed upon a good consideration cannot be rebutted by evidence, so long as the bond is unimpeached, that is, so long as it is admitted to be a bond. But though the law presumes that a bill of exchange was accepted on good consideration, it admits evidence to show that such was not the fact. Now this presumption of law is nothing more than a fact presumed by a judge or judges, to which fact so presumed, certain legal consequences are annexed or belong. It is however a very inaccurate expression to speak of a presumption of law; for, "when the law presumes or infers any fact to which a legal consequence is annexed from any defined predicament of facts, the law in effect indirectly annexes to that predicament the legal consequence which belongs to the presumed fact."

One presumption of law may be opposed by another, and the law, that is, the court, must then decide which is the stronger.

Presumptions of *mere law,* as shown, are such as are made by the court. There are instances of presumptions made by act of parliament, that is, the legislature has declared that a certain fact or facts, when proved, shall be conclusive proof of another unproved fact which is not a necessary, and, it may be, is often not a highly probable inference from the proved fact. A statute of 21 James I., c. 27 (now repealed), made proof of the concealment of the death of a bastard child by the mother conclusive evidence of her having murdered it, unless she could prove that it was born dead. And sometimes an act of parliament declares that a certain presumption shall not be allowed or made. (2 and 3 Wm. IV., c. 71, s. 6.) A presumption of mere law is sometimes called an *intendment* of law.

Presumptions of *law* and *fact* are artificial presumptions, recognised and warranted by the law as the proper inferences to be made by juries under particular circumstances. In other words, these are facts which the law, that is, the court, will allow a jury to presume from other facts proved by direct evidence. When the presumed fact is declared by the jury to be a real fact, or is implicitly contained in their verdict, the legal effect is the same. It is said that the inference (made by the jury) is never conclusive, which appears to mean that there are presumptions which are not necessary, and sometimes may not be highly probable, but they are still such as a jury may make (at least under the direction and advice of the court), and their verdict will be good. Thus a jury is required, or at least advised by a court to infer a grant of an incorporeal hereditament after an adverse enjoyment for the space of twenty years. The presumption of right in such cases is not however conclusive; in other words, it is not an inference of *mere law* to be made by the courts, yet it is an inference which the courts advise juries to make whenever the presumption stands unrebutted by contrary evidence. Such evidence in theory is mere presumptive evidence; in practice and effect it is a bar.

The third class, the natural presumptions of *mere fact,* are wholly independent of any artificial legal relations and connections, and differ from presumptions of mere law in this essential respect, that those depend upon or rather are a branch of the particular system of jurisprudence to which they belong; but mere natural presumptions are derived wholly by means of the common experience of mankind from the course of nature and the ordinary habits of society. This class of presumptions properly belongs to a jury, and yet the courts will sometimes make presumptions of this kind without the aid of a jury. These presumptions then are such as a jury may make without the advice or direction of the court, and it seems therefore to be a general rule, that whenever there is evidence on which a jury have founded a presumption according to the justice of the case, the courts will not grant a new trial.

Presumption then is either a positive rule by which a certain conclusion is declared by statute, or by the judges, or by the jury under the direction and advice of the judges, to follow from certain other proved facts; or it is a conclusion from certain other proved facts which a judge or a jury may make if they find the probative force of the proved facts sufficient to induce them to make the inference called a natural presumption, or presumption of mere fact. Presumptions therefore are incident to every head of law in which proof is required; and the presumptions which are positive rules of law are part of the law of the things to which they relate.

The term "præsumptio" occurs occasionally in the 'Digest,' and in the sense of an inference from a fact proved or admitted. ('Dig.', 22, tit. 3. s. 25.)

(Bentham, *Rationale of Judicial Evidence;* Starkie, *On Evidence;* Phillips, *On Evidence.*)

PRESUMPTIVE HEIR. [Descent.]

PRICE. [Value; Wages.]

PRIEST (Saxon, *preost,* from the Greek *πρεσβύτερος, an elder*), in its popular acceptation, is the name of a minister of religion in all ages and countries.

Priest is used to express the Greek *hiereus* (ἱερεύς) and the Latin *sacerdos*, which signify in general a sacrificer. Whatever may be the primitive meaning of the Hebrew word *cohen*, it is rendered in the Septuagint by ἱερεύς, and its usage plainly shows that it denotes a sacrificer. An elder, *zaken*, has πρεσβύτερος as its corresponding word. In Wycliffe's New Testament, which is a translation from the Vulgate, priest, answering to the Latin presbyter, several times occurs, where the authorised version has elder.

Priest in the formularies of the Church of England is used in its original sense of presbyter, and points out the second degree of the ministers, to be admitted to which a man must be, according to the 34th canon, of the age of "four and twenty years complete."

The existence of an official person to act in some way between the Deity and man appears among the earliest notices of history, whether sacred or profane. In the Book of Genesis, Melchisedec is named "Priest of the most high God." Among the Jews an order of men existed who were especially appointed by God to minister in holy things, and whose qualifications and functions are set forth at large in the writings of Moses. The Egyptians had great numbers of priests, who had lands in the time of Joseph. (Gen. xlvii. 22.) In the first ages of the Greeks, the same person was mostly their priest and king. In the course of time the office of priest became distinct, and sometimes women, as well as men, were appointed to this office. It is probable, however, that the most ancient priesthood among all nations was that which fathers or heads of families exercised over their own dependents; and thus it will appear that kingly government and sacerdotal authority of some kind or other would naturally spring from the paternal relation. (Shuckford's 'Connection of Sacred and Profane History.')

PRIMATE. [ARCHBISHOP.]

PRIME. A number is said to be prime when it is not divisible without remainder by any less number than itself, except unity. Thus 1, 2, 3, are of necessity prime; 4 is not, being divisible by 2; 5 is prime, and so are 7, 11, 13, 17, 19, 23, 29, 31, &c.

Large lists of prime numbers have been published [TABLES], but they are seldom possessed by the elementary student. As it is, however, frequently desirable to know whether a number not exceeding 10,000 is prime or not, we shall give a table to that extent, the manner of using which is as follows:—If we wish to know whether 2897 be a prime number, under the heading 2 and in the column 8 we look for 97, which we find there: whence the table shows that 2897 is a prime number. Again, by the same means we find that 1457 is not a prime number, the adjacent prime numbers being 1453 and 1459.

0

0	1	2	3	4	5	6	7	8	9
1	01	11	07	01	03	01	01	09	7
2	03	23	11	09	09	07	09	11	11
3	07	27	13	19	21	13	19	21	19
5	09	29	17	21	23	17	27	23	29
7	13	33	31	31	41	19	33	27	37
11	27	39	37	33	47	31	39	29	41
13	31	41	47	39	57	41	43	39	47
17	37	51	49	43	63	43	51	53	53
19	39	57	53	49	69	47	57	57	67
23	49	63	59	57	71	53	61	59	71
29	51	69	67	61	77	59	69	63	77
31	57	71	73	63	87	61	73	77	83
37	63	77	79	67	93	73	87	81	91
41	67	81	83	79	99	77	97	83	97
43	73	83	89	87		83		87	
47	79	93	97	91		91			
53	81			99					
59	91								
61	93								
67	97								
71	99								
73									
79									
83									
89									
97									

1

0	1	2	3	4	5	6	7	8	9
09	03	01	01	09	11	01	09	01	01
13	09	13	03	23	23	07	21	11	07
19	17	17	07	27	31	09	23	23	13
21	23	23	19	29	43	13	33	31	31
31	29	29	21	33	49	19	41	47	33
33	51	31	27	39	53	21	47	61	49
39	53	37	61	47	59	27	53	67	51
49	63	49	67	51	67	37	59	71	73
51	71	59	73	53	71	57	77	73	79
61	81	77	81	59	79	63	83	77	87
63	87	79	99	71	83	67	87	79	93
69	93	83		81	97	69	89	89	97
87		89		83		93			99
91		91		87		97			
93		97		89		99			
97				93					
				99					

2

0	1	2	3	4	5	6	7	8	9
03	11	03	09	11	03	09	07	01	03
11	13	07	11	17	21	17	11	03	09
17	29	13	33	23	31	21	13	19	17
27	31	21	39	37	39	33	19	33	27
29	37	37	41	41	43	47	29	37	39
39	41	39	47	47	49	57	31	43	53
53	43	43	51	59	51	59	41	51	57
63	53	51	57	67	57	63	49	57	63
69	61	67	71	73	79	71	53	61	69
81	79	69	77	77	91	77	67	79	71
83		73	81		93	83	77	87	99
87		81	83			87	89	97	
89		87	89			89	91		
99		93	93			93	97		
		97	99			99			

3

0	1	2	3	4	5	6	7	8	9
01	09	03	01	07	11	07	01	03	07
11	19	09	07	13	17	13	09	21	11
19	21	17	13	33	27	17	19	23	17
23	37	21	19	49	29	23	27	33	19
37	63	29	23	57	33	31	33	47	23
41	67	51	29	61	39	37	39	51	29
49	69	53	31	63	41	43	61	53	31
61	81	57	43	67	47	59	67	63	43
67	87	59	47	69	57	71	69	77	47
79	91	71	59	91	59	73	79	81	67
83		99	61	99	71	77	93	89	89
89			71		81	91	97		
			73		83	97			
			89		93				
			91						

4

0	1	2	3	4	5	6	7	8	9
01	11	01	27	09	07	03	03	01	03
03	27	11	37	21	13	21	21	13	09
07	29	17	39	23	17	37	23	17	19
13	33	19	49	41	19	39	29	31	31
19	39	29	57	47	23	43	33	61	33
21	53	31	63	51	47	49	51	71	37
27	57	41	73	57	49	51	59	77	43
49	59	43	91	63	61	57	83	89	51
51	77	53	97	81	67	63	87		57
57		59		83	83	73	89		67
73		61		93	91	79	93		69
79		71			97	91	99		73
91		73							87
93		83							93
99		89							99
		97							

5

0	1	2	3	4	5	6	7	8	9
03	01	09	03	07	01	23	01	01	03
09	07	27	09	13	03	39	11	07	23
11	13	31	23	17	07	41	17	13	27
21	19	33	33	19	19	47	37	21	39
23	47	37	47	31	21	51	41	27	53
39	53	61	51	37	27	53	43	39	81
51	67	73	81	41	31	57	49	43	87
59	71	79	87	43	57	59	79	49	
77	79	81	93	49	63	69	83	51	
81	89	97	99	71	69	83	91	57	
87	97			77	73	89		61	
99				79	81	93		67	
				83	91			69	
								79	
								81	
								97	

6

0	1	2	3	4	5	6	7	8	9
07	01	03	01	21	21	07	01	03	07
11	13	11	11	27	29	19	03	23	11
29	21	17	17	49	47	37	09	27	17
37	31	21	23	51	51	53	19	29	47
43	33	29	29	69	53	59	33	33	49
47	43	47	37	73	63	61	37	41	59
53	51	57	43	81	69	73	61	57	61
67	63	63	53	91	71	79	63	63	67
73	73	69	59		77	89	79	69	71
79	97	71	61		81	91	81	71	77
89	99	77	67		99		91	83	83
91		87	73				93	99	91
		99	79						97
			89						
			97						

7

0	1	2	3	4	5	6	7	8	9
01	03	07	07	11	07	03	03	17	01
13	09	11	09	17	17	07	17	23	07
19	21	13	21	33	23	21	23	29	19
27	27	19	31	51	29	39	27	41	27
39	29	29	33	57	37	43	41	53	33
43	51	37	49	59	41	49	53	67	37
57	59	43	51	77	47	69	57	73	49
69	77	47	69	81	49	73	59	77	51
79	87	53	93	87	59	81	89	79	63
	93	83		89	61	87	93	83	93
		97		99	73	91			
					77	99			
					83				
					89				
					91				

8

0	1	2	3	4	5	6	7	8	9
09	01	09	11	19	01	09	07	03	23
11	11	19	17	23	13	23	13	07	29
17	17	21	29	29	21	27	19	19	33
39	23	31	53	31	27	29	31	21	41
53	47	33	63	43	37	41	37	31	51
59	61	37	69	47	39	47	41	37	63
69	67	43	77	61	43	63	47	39	69
81	71	63	87	67	63	69	53	49	71
87	79	69	89		73	77	61	61	99
89	91	73			81	81	79	63	
93		87			97	89	83	67	
		91			99	93		87	
		93				99		93	
		97							

9

0	1	2	3	4	5	6	7	8	9
01	03	03	11	03	11	01	19	03	01
07	09	09	19	13	21	13	21	11	07
11	27	21	23	19	33	19	33	17	23
13	33	27	37	21	39	23	39	29	29
29	37	39	41	31	47	29	43	33	31
41	51	41	43	33	51	31	49	39	41
43	57	57	49	37	87	43	67	51	49
49	61	77	71	39		49	69	57	67
59	73	81	77	61		61	81	59	73
67	81	83	91	63		77	87	71	
91	87	93	97	67		79	91	83	
	99			73		89		87	
				79		97			
				91					
				97					

The distribution of the prime numbers does not follow any discoverable law, but it begins to be evident from the preceding table, that in a given interval the number of primes is generally less, the higher the beginning of the interval is taken. The following table will set this in a clearer light: the numbers in the first column mean thousands, and in the second column are found the numbers of primes which lie in the interval specified in the first column. Thus, between 10,000 and 20,000 lie 1033 primes.

In the first 10,000 numbers, upwards of 12 per cent. are primes; but between 900 thousand and a million, only 7¼ per cent. are primes. The annexed enumerations are taken from Legendre's Theory of Numbers, and were made from the large tables of primes given by Vega, Chernac, and Burkhardt. The only thing known relative to the proportions of prime numbers to others is that if x be a very large number, the number of primes contained between 0 and x is nearly $x \div (\log x - 1{\cdot}08366)$, $\log x$ being the Naperean logarithm. This very curious theorem was discovered empirically, that is, by looking for a formula which should nearly represent the results of tables. Legendre, in the work cited, gave proof that such a formula must have the form

Between	No. of Primes.
0 and 10 . . .	1230
10 „ 20 . . .	1033
20 „ 30 . . .	983
30 „ 40 . . .	958
40 „ 50 . . .	930
50 „ 60 . . .	924
60 „ 70 . . .	878
70 „ 80 . . .	901
80 „ 90 . . .	876
90 „ 100 . . .	879
100 „ 150 . . .	4257
150 and 200 . . .	4135
200 „ 250 . . .	4061
250 „ 300 . . .	3943
300 „ 350 . . .	3989
350 „ 400 . . .	3884
400 „ 500 . . .	7677
500 „ 600 . . .	7555
600 „ 700 . . .	7442
700 „ 800 . . .	7402
800 „ 900 . . .	7331
900 „ 1000 . . .	7225

$x \div (\text{A} \log x - \text{B})$, but no reason has yet been given why A is 1, and B is 1·08366. Using the common logarithm, we find that the number of primes less than x is such a proportion of x as ·4342945 is of $\log x -$ ·470628, nearly. Thus, of all numbers less than a million of million of millions, only one out of 40 is prime, while the number of primes under the square of that number is one out of 82.

It thus appears that we might name a succession of numbers beginning with one so high, that a million, or any other number however great, of numbers should pass without containing one prime number. Nevertheless there cannot be an end to the prime numbers; for if so, let p be the last prime number, and let N be the product of all the prime numbers, 2, 3, 5, ... , p. Now every number is either prime or divisible by a prime; but $\text{N}+1$ is not divisible by 2, 3, 5, ... or p, since it leaves a remainder 1 in every such division. It is therefore prime, or there is a prime number $\text{N}+1$, greater than the greatest prime number p, which is absurd. The following are among the properties of prime numbers:—(1.) Every prime number (except 2) is odd, or of the form $2x+1$. (2.) Every prime is of the form $4x+1$ or $4x+3$, and a prime of the form $4x+1$ is always the sum of two squares. (3.) Every prime is of the form $6x+1$ or $6x+5$. (4.) No algebraical formula can always represent a prime number; but some formulæ show a long succession of primes: thus x^2+x+41 is prime from $x=0$ to $x=39$, both inclusive. (5.) If $2x+1$ be a prime number, and N any number which it does not divide, either $\text{N}^x - 1$ or $\text{N}^x + 1$ must be divisible by $2x+1$. (6.) If M and N be two prime numbers, and if $\text{M}=2x+1$, $\text{N}=2y+1$, then if x and y be both odd numbers, either $(\text{M}^y - 1) : \text{N}$ and $(\text{N}^x - 1) : \text{M}$ are both whole numbers, or $(\text{M}^y + 1) : \text{N}$ and $(\text{N}^x + 1) : \text{M}$ are both whole numbers. But if x and y be not both odd, then either $(\text{M}^y - 1) : \text{N}$ and $(\text{N}^x + 1) : \text{M}$ are both whole numbers, or else $(\text{M}^y + 1) : \text{N}$ and $(\text{N}^x - 1) : \text{M}$ are both whole numbers. This theorem is of considerable importance in the theory of numbers, and has been termed the law of reciprocity of prime numbers.

Two numbers are said to be prime *to one another*, when they have not any common measure except unity: as 36 and 55.

The prime factors of a number are those prime numbers which divide it. Thus, 360 being $2^3 \times 3^2 \times 5$, its prime factors are 2, 3, 5, of which the first enters three times, the second twice, and the third once. If A, B, C, ... be the prime factors of a number, and $a, b, c,$ . . . the number of times which they severally enter, the number is $\text{A}^a \times \text{B}^b \times \text{C}^c \times$ . . . . . and the number of divisors which it admits of (unity and itself included) is $(a+1) \times (b+1) \times (c+1) \times$ . . . . Let A^a, B^b . . . . be N: then the number of numbers less than N, and prime to N, is

$$\text{N} \times \frac{a-1}{a} \times \frac{b-1}{b} \times \frac{c-1}{c} \times \ldots.$$

PRIME AND ULTIMATE RATIOS. [RATIOS, PRIME AND ULTIMATE; DIFFERENTIAL CALCULUS.]

PRIMERO, a game at cards, so called from a situation in the game. He who holds the *prime* (primero), that is, a sequence of the best cards and a good trump, is sure to be successful over his adversaries; hence its denomination. *Primero*, *prime*, and *primavista* were one and the same game.

Primero appears to have been one of the earliest games at cards played in England, and continued to be the most fashionable game throughout the reigns of Henry VIII., Edward VI., Mary, Elizabeth, and James. In the Earl of Northumberland's letters relating to the powder-plot, we find that Josceline Percy was playing at primero on Sunday, when his uncle, the conspirator, called on him at Essex-house. Shakspere speaks of Henry VIII. playing at primero with the Duke of Suffolk.

(Singer's 'Researches into the History of Playing Cards,' 4to, Lond., 1816.)

PRIMOGENITURE may be defined to be that rule of English law by which a title of dignity or an estate in land comes to a person in respect of his being an eldest male. If a man dies seised of real estate, of which he had the absolute ownership, without having made any disposition of it by his last will, the whole descends to the heir at law, or customary heir; and the heir at law is such by virtue of being the eldest male person of those who are in the same degree of kindred to the person dying, or the representative of such eldest male. [DESCENT.] This is a case in which primogeniture operates. A common example of primogeniture is where a father dies absolutely entitled to real estate, and without disposing of it by will, in which case his eldest son takes it all. If land is settled or entailed on a man and his male issue, the eldest son takes the land by two titles, first as being a male, and next as being the eldest son. The law of primogeniture then only applies in the case of land when the owner dies without having made any disposition of it by will, or where the land is settled on a man and his male issue. It does not apply when the interest in land is a chattel interest, or a term of years, whatever may be its duration; nor does it apply when real estate descends to daughters as coparceners.

At present those who are the absolute owners of large landed estates seldom die without making a disposition of them by will. In the case of lands which are settled, the person in possession is generally tenant for life, and the inheritance is entailed on the eldest son. When the eldest son is about to marry, it is usual for the father and son to take the usual legal steps (which they can do as soon as the son is of age) to unsettle the estate and obtain the absolute ownership. They then resettle the estate, making the father tenant for life as before; the son, who was before tenant in tail, is also made only a tenant for life; and the inheritance is settled, as before, on the eldest son of the intended marriage. Such eldest son takes the estate, not as heir, and therefore not by the law of primogeniture, but he takes it as the person designated by the deed of settlement.

When a man happens to be tenant in tail, he usually takes the legal steps necessary (which he can do as soon as he is of age) to acquire the absolute ownership of the property, which he then generally settles again by deed or will, or disposes of absolutely.

It is usual in England to settle all large estates, and the object of the settlement is to keep the estates together, and to perpetuate them in one family; but there is a limit to this power of settlement. A man cannot, either by deed or will, settle his land, so as to prevent the absolute ownership of it from being obtained, for a longer period than a life or lives of persons in existence at the time when the settlement takes effect, and twenty-one years more.

Lands in GAVELKIND and BOROUGH ENGLISH are an exception to the general rule of law as to the descent of land.

The law of primogeniture then only operates in the cases already explained; and the system of settlements by which property is kept together in large masses is quite distinct in principle from the law of primogeniture. It is not the result of a law which favours primogeniture, but it is the result of the legal power which an owner of land has over it, and of the habits of the people. The various reasons which have laid the foundation of this habit, and which perpetuate it, are foreign to the consideration of primogeniture as a rule of law.

In Virginia, after the Revolution, an Act was passed for converting estates tail into fee-simple, and at the same time the law of primogeniture was abolished. These laws have so far been in accordance with or have acted on public opinion, that a parent by his will now generally makes the same disposition of his property as the law makes in case he dies intestate. (Tucker's 'Life of Jefferson,' i. 96, &c.)

(*Remarks on Primogeniture and Entails*; Hayes, *Introduction to Conveyancing*.)

PRIMULIN. A crystallisable non-azotised matter of unknown composition, found in the root of the primrose.

PRIMUM MO'BILE, the name given in the old astronomy to the imaginary sphere by the motion of which diurnal motion was given to the heavens. [PTOLEMAIC SYSTEM.]

PRINCE is the Latin word *princeps*, which was originally used to denote the person who was entitled princeps senatus in the Roman State. He seems to have been originally the custos of the city, and his office was one of importance. Subsequently it became a title of dignity, and the princeps was named by the censors. (Liv. xxvii. 2.) In the senate he gave his opinion first after the magistratus. Augustus and his successors adopted the title of princeps, as a name that carried no odium with it: and this became henceforward the characteristic title of the master of the Roman world. Accordingly the constitutions of the emperors are called principum (Gaius i. 2) or principales. The word princeps is formed similarly to anceps, municeps, &c., and contains the same element as "primus." In the course of time the word prince, which is derived from princeps, has come to be applied to persons having personal pre-eminence, and especially to certain sovereigns of smaller states possessing either perfect independence of all others or enjoying under some superior high political rights. Of the first kind were the old sovereigns of Wales, who, under the name of princes, enjoyed the same right and power which belong to kings; and of the second, the heads of certain states of Germany, comprehended in the great Germanic confederation. But the word seems not to have acquired so definite a sense as that which belongs to king, duke, marquess, earl, and some others of the class; but rather to denote persons of eminent rank in certain states, as in Prussia, Russia, Italy, and other continental states, where no sovereignty, properly so called, comes along with it, or persons who are junior members of sovereign houses, as the younger members of the ducal families of Saxe and Anhalt. Frequently, however, such members have specific titles given, such as duke, count, &c., but never prince.

In England it has sometimes been the practice of the heralds to speak of a duke as the high and mighty prince; but the word seems rather to be restricted among us in its application to persons who are of the blood-royal, that is, a son, grandson, or nephew of a king; and it would probably be extended to the remote male posterity, though no such case has arisen in the course of the last three centuries. But in its application it is merely a term of common parlance, not being conferred, like the title of duke, in any formal manner; and even the precedence which is given to blood-royal has respect to birth, and not to the enjoyment of this word as a title of honour. The eldest son of the sovereign is however made Prince of Wales by a special act of creation; the younger sons are princes until they have other titles conferred; the daughters continue princesses.

PRINCE'S METAL. A kind of brass composed of 75 parts of copper and 25 parts of zinc.

PRINCIPAL. [AGENT.]

PRINCIPAL, the name of a stop or row of metal pipes in an organ, tuned an octave higher than the diapason, an octave lower than the fifteenth, and serving to blend the two, as well as to augment the volume of sound.

PRINCI'PIA, the contracted title of the 'Philosophiæ Naturalis Principia Mathematica,' the great work of Newton, the publication of which is the most remarkable known epoch in the history of science. The title-page of the first edition is: 'Philosophiæ Naturalis Principia Mathematica. Autore Is. Newton, Trin. Coll. Cantab., Soc. Matheseos Professore Lucasiano, et Societatis Regalis Sodali. Imprimatur. S. Pepys, Reg. Soc. Præses, Julii 5, 1686. Londini Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.'

We entirely pass over the common story of the fall of an apple. [Newton, in Biog. Div.] It appears in the rough copy left among Newton's papers of the information furnished to Fontenelle for his *éloge* of Newton: but as Fontenelle did not give it, though very much given to anecdote, it may be inferred that Mrs. Conduitt, Newton's niece, struck it out before it was sent. It is clear however that Newton first thought on the subject in 1666. With reference to the story of his laying by the theory until Picard's measure of the earth was brought to his notice in 1682, it appears that Picard's 'Mésure de la Terre' was published in 1672, and much discussed at the Royal Society in the years following.* Moreover Dr. Pemberton, who derived his information from Newton himself, states most explicitly (in his preface) that a letter from Hooke gave occasion to his resuming his old thoughts, and that he then used Picard's measure. This letter from Hooke, the subject of which was the curve in which a falling body descends to the earth, taking into account the earth's motion, is clearly made out to have been written in 1679, which is therefore the date of Newton's resumption of his attempt, not 1682, as generally stated. The new attempt, as every one knows, was more successful, but Newton did not write any treatise nor contemplate any publication; he traced out the foundation of his system, and threw aside his papers. In January,† 1684, Halley had concluded, from Kepler's third law, that the centripetal force on the planets (supposed to move in *circles*) was as the inverse square of the distance. Not being able to proceed further, he applied to Hooke and Wren, the former of whom professed to have solved the whole problem, but would communicate nothing; the latter declared that he had long given over the question from inability to succeed. In August following, Halley paid a visit to Newton at Cambridge, who informed him that he had solved the problem, but *was not able to lay his hand on the papers which contained his solution*, so completely had he thrown the subject aside. After Halley's departure, he worked the theorems out again, and transmitted them to Halley through Mr. Paget, the mathematical master at Christ's Hospital. On receipt of this communication, in November, Halley immediately paid another visit to Cambridge, to gain more information, and to induce Newton to pursue the inquiry. December 10, 1684, Halley stated at the Royal Society that "he had lately seen Mr. Newton at Cambridge, and that he had shown him a curious treatise 'De Motu,' which, upon his desire, he said was promised to be sent to the Society, to be entered upon their register." Halley and Paget were accordingly deputed to keep Newton in mind of his promise (a singular proceeding, showing how well the Society knew Newton's indifference about communicating), and the consequence was, that about the middle of February, 1685, a communication (that previously made to Halley, enlarged), entitled 'Isaaci Newtoni Propositiones de Motu,' was sent and registered: it contains what were afterwards the main theorems of the early sections of the Principia, direct and inverse, relating to centripetal forces. No Principia as yet existed, and even this basis had only recently been written down satisfactorily. Newton writes to Mr. Aston, Sec. R.S., in acknowledging the news of the above entry, "I designed them for you before now, but the examining several things has taken a greater part of my time than I expected, and a great deal of it to no purpose. And now I am to go into Lincolnshire for a month or six weeks. *Afterwards I intend to finish it* as soon as I can conveniently." (February 23, 1685.) On this Mr. Rigaud well remarks, "The Principia was not a protracted compilation from memoranda which might have been written down under the impression of different trains of thought: it had the incalculable advantage of being composed by one continued effort, during which the mutual bearing of the several parts was vividly present to the author's mind." On the 21st of April, 1686, Halley announced to the Royal Society that Mr. Newton "had an incomparable Treatise on Motion almost ready for the press;" and on the 28th of the same month Dr. Vincent‡ presented the manuscript of the first book to the Society, who referred the question of printing to the Council, and the production of a report upon the contents to Halley. May 19, the Society decided that the work should be printed forthwith in quarto, &c.; and hence it has always been supposed that the Society paid the expenses of printing, though the title-page only bears "jussu Societatis," &c., and not "jussu et sumptibus," as usual where it bore the expenses. But Mr. Rigaud quotes the minute of the *Council* of the Society of the 2nd of June, confirming the vote of the *Society* to the extent of resolving "that Mr. Newton's book be printed," but adding that "E. Halley shall undertake the business of looking after it, *and printing it at his own charge, which he engaged to do*." The fact was, that when the Council came to consider the Society's vote of the 19th of May, they found there was no money; a work of Francis Willughby, 'De Historia Piscium,' published "jussu et sumptibus," in 1686, had so reduced their funds, that they were obliged to pay their officers in copies of this very book about fishes.

In the meanwhile arose a controversy with Hooke, the universal claimant, who, when the first part of the manuscript was presented by Vincent, asserted that he had discovered the law of the inverse squares, and had communicated that and other discoveries to Newton. The heads of the paper on which he founds his claim are given at length in Hooke, Robert, in Biog. Div., and they show that though he had (in common with several others) some very correct notions on the subject, he had not even arrived at the knowledge of the law of the inverse squares, though that had been propounded by Bouillaud [Biog. Div.]. Mr. Rigaud enters at great length into this question; if we were to do the same, we should take an advanced position, and before we attempted to show that Hooke did not write any part of the substance of the Principia, we should require reasonable proof that he would have been able to read and understand the mathematical part of it when written: and not until this had been given, which we are convinced could not be given from Hooke's writings, should we consider it necessary to enter on the first point. Had it not been for Halley, this trumpery claim of Hooke's would have produced serious consequences. Newton, easily disgusted by controversy, and having observed that physical questions generally gave rise to it, proposed (in a letter to Halley, June 20, 1686) to omit the third book altogether, which contains the actual application of the first two books to the existing universe. He says, "The third I now design to suppress. Philosophy is such an impertinently litigious lady, that a man had as good be engaged in lawsuits as have to do with her. I found it so formerly, and now I have no sooner come near her again, but she gives me warning. The two first books, without the third, will not so well bear the title of 'Philosophiæ Naturalis Principia Mathematica,' and therefore I had altered it to this,—'De Motu Corporum Libri Duo,' but upon second thoughts, I retain the former title. 'Twill help the sale of the work, which I ought not to diminish now 'tis yours." Halley had to soothe this irritation, and prevent the consequences; and as the letter in which he did this is very curious, and has never been printed altogether, except by Mr. Rigaud, the surpassing interest which everything connected with the Principia excites will justify our giving it entire, particularly as it is the original voucher for several of the most important circumstances connected with the publication:—

"London, 29 June, 1686.

"Sir,—I am heartily sorry that in this matter, wherein all mankind ought to acknowledge their obligations to you, you should meet with anything that should give you disquiet; or that any disgust should make you think of desisting in your pretensions to a lady whose favours you have so much reason to boast of. 'Tis not she, but your rivals, envying your happiness, that endeavour to disturb your quiet enjoyment; which, when you consider, I hope you will see cause to alter your resolution of suppressing your third book, there being nothing which you can have compiled therein, which the learned world will not be concerned to have concealed. Those gentlemen of the Society to whom I have communicated it, are very much troubled at it, and that this unlucky business should have happened to give trouble, having a just sentiment of the author thereof. According to your desire in your former, I waited upon Sir Christopher Wren, to inquire of him, if he had the first notion of the reciprocal duplicate proportion from Mr. Hooke. His answer was, that he himself very many years since had had his thoughts upon the making out the planets' motions by a composition of a descent towards the sun, and an impressed motion; but that at length he gave it over, not finding the means of doing it. Since which time Mr. Hooke had frequently told him, that he had done it, and attempted to make it out to him; but that he never was satisfied that his demonstrations were cogent. And this I know to be true, that in January, 1683-4, I, having, from the considerations of the sesquialter proportion of Kepler, concluded that the centripetal force decreased in the proportion of the squares of the distances reciprocally, came on Wednesday to town, where I met with Sir Christopher Wren and Mr. Hooke, and falling in discourse about it, Mr. Hooke affirmed, that upon that principle all the laws of the celestial motions were to be demonstrated, and that he himself had done it. I declared the ill-success of my own attempts; and Sir Christopher, to encourage the inquiry, said that he would give Mr. Hooke, or me, two months' time to bring him a convincing demonstration thereof; and, besides the honour, he of us, that did it, should have from him a present of a book of forty shillings. Mr. Hooke then said, that he had it, but he would conceal it for some time, that others trying and failing might know how to value it, when he should make it public. However, I remember that Sir Christopher was little satisfied that he could do it; and though Mr. Hooke then promised to show it him, I do not find that in that particular he has been so good as his word. The August following, when I did myself the honour to visit you, I then learnt the good news that you had brought this demonstration to perfection: and you were pleased to promise me a copy thereof, which the November following I received with a great deal of satisfaction from Mr. Paget; and thereupon took another journey to Cambridge, on purpose to confer with you about it, since which time it has been entered upon the Register books of the Society. As all this passed, Mr. Hooke was acquainted with it, and according to the philosophically ambitious temper he is of, he would, had he been master of a like demonstration, no longer have concealed it, the reason he told Sir Christopher and me now ceasing. But now, he says, this is but one small part of an excellent system of nature, which he has conceived, but has not yet completely made out, so that he thinks not fit to publish one part without the other. But I have plainly told him, that unless he produce another differing demonstration, and let the world judge of it, neither I nor any one else can believe it. As to the manner of Mr. Hooke's claiming the discovery, I fear it has been represented in worse colours than it ought; for he neither made public application to the Society for justice, nor pretended you had all from him. The truth is this: Sir John Hoskyns, his particular friend, being in the chair when Dr. Vincent presented your book, the Doctor gave it its just encomium both as to the novelty and dignity of the subject. It was replied by another gentleman, that you had carried the thing so far, that there was no more to be added. To which the Vice-president replied, that it was so much the more to be prized, for that it was both invented and perfected at the same time. This gave Mr. Hooke offence, that Sir John did not, at that time, make mention of what he had, as he said, discovered to him; upon which they two, who till then were the most inseparable cronies, have since scarce seen one another, and are utterly fallen out. After the breaking up of that meeting, being adjourned to the coffee-house, Mr. Hooke did there endeavour to gain belief, that he had some such thing by him, and that he gave you the first hint of this invention. But I found, that they were all of opinion, that, nothing thereof appearing in print, nor on the books of the Society, you ought to be considered as the inventor. And if in truth he knew it before you, he ought not to blame any but himself, for having taken no more care to secure a discovery which he puts so much value on. What application he has made in private, I know not; but I am sure that the Society have a very great satisfaction, in the honour you do them, by the dedication of so worthy a treatise. Sir, I must now again beg you, not to let your resentments run so high, as to deprive us of your third book, wherein the application of your mathematical doctrine to the theory of comets and several curious experiments, which, as I guess by what you write, ought to compose it, will undoubtedly render it acceptable to those who will call themselves Philosophers without Mathematics, which are much the greater number. Now you approve of the character and paper, I will push on the edition vigorously. I have sometimes had thoughts of having the cuts neatly done in wood, so as to stand in the page with the demonstrations. It will be more convenient, and not much more charge. If it please you to have it so, I will try how well it can be done; otherwise I will have them in somewhat a larger size than those you have sent up. I am, Sir, your most affectionate humble servant, "E. Halley."

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* Rigaud mentions that Newton must have been acquainted with the measures of Snell and Norwood, the result of the former of which appears in his own edition of Varenius. The latter, there can be no doubt, he did not trust; and as to the former, we have shown [Mile] that in this very edition of Varenius, he had allowed gross errors to pass as to the measures of his own country. It may be inferred that he had not much to do with the details of it.

† That is, what we call 1684; Halley writes 1683-4. [Periods of Revolution.] All the following dates are for a year beginning in January.

‡ This gentleman has been (wrongly) supposed to have been the husband of a lady to whom Newton was attached in early life.

The authorities on this subject are—1, Rigaud, 'Historical Essay on the First Publication of the Principia,' Oxford, 1838, 8vo.; 2, Edleston, 'Correspondence of Sir I. Newton and Prof. Cotes,' London, 1850, 8vo.; 3, Brewster, 'Memoirs of Sir I. Newton,' London, 1855, 2 vols. 8vo. Rigaud's research was of the most acute and accurate character. Mr. Edleston has added a biography in the form of *annals* with notes, the most convenient reference on Newton which exists: and his researches, especially those made in Trinity College, have been laborious and successful. Sir D. Brewster had the celebrated Portsmouth papers in his possession, and has produced the most detailed life of Newton which exists. An immense deal has been done for the biography of Newton in the last twenty-five years: but the subject will never be finally settled until the Portsmouth papers have been allowed to undergo the most searching and leisurely scrutiny from men of all opinions on disputed points.

Newton had completed the first draught of the work by the end of 1685, though none of it was sent till April, 1686. The third book was presented to the Society, April 6, 1687, in proof, probably, since the whole was published (at ten or twelve shillings a copy) about Midsummer, 1687. The order of the Council of the Society to license the book was made on June 20, 1686, and the imprimatur of Pepys was dated July 5.

The part which Halley had in the matter would alone immortalise his name. He found out the ability of Newton to write such a work, prevailed upon him to write it, took charge of the publication, prevented the author from materially mutilating it in disgust, paid the expenses of printing, at a time when, owing to his father's death and consequent litigation, he had nothing to spare (which never happened to him before or after), gave a copious explanation of it in the Philosophical Transactions, and is generally admitted to have been for a long time the only person in Europe who showed that he thoroughly appreciated the value of the work, and knew the place it must occupy in the history of discovery.

The interest attached to the second and third editions of the Principia (superintended by Cotes in 1713, and by Pemberton in 1726) is considerable, with reference to the alterations made in them by Newton. It would not however be worth while to specify these alterations, which are numerous, some in correction of errors, others in extension of views. With reference to the suppression of the celebrated Scholium, see Commercium Epistolicum and Fluxions.

The Principia of Newton contains the dedication to the Royal Society, a short preface, verses by Halley in honour of Newton, definitions, axioms, a first book on unresisted motion, a second on resisted motion, and a third on the system of the universe. Halley's verses were somewhat altered by Bentley in the second edition, but the original readings were very nearly restored in the third. Newton wrote a short preface for each of the editions, and Cotes one of considerable length for the second. The dates of the Newtonian prefaces are, May 8, 1686; March 28, 1713; January 12, 1725–6. The following is the description of the contents of the third edition:

The definitions comprise, 1. Quantity of matter measured by density and volume jointly. 2. Quantity of motion [Momentum] by velocity and quantity of matter jointly. 3. Vis insita, or vis inertiæ. [Inertia.] 4. Vis impressa, or external force. 5. Centripetal force. 6. Absolute magnitude of centripetal force. 7. Accelerating force. 8. Moving force. A scholium is added on time, space, and motion, the latter considered absolutely and relatively.

The axioms are the three laws of motion [Motion, Laws of] and certain corollaries, namely:—1. The composition of velocities and forces. 2. Their resolution, and deduction of the property of the lever. 3. Momentum of a system in a given direction not changed by the mutual action of the parts. 4. Nor the motion of the centre of gravity. 5. Relative motion of bodies not altered by absolute motion of the space they move in. 6. Nor by equal and parallel accelerating forces applied to all. A scholium is added, containing the experimental verifications of the third law in the cases of impact, attraction, and operation of machines.

The First Book * on unresisted motion, consists of fourteen sections, and ninety-eight propositions. The numbers in parentheses refer to the propositions.

Section 1 contains eleven lemmas and a scholium. This section is explanatory of Newton's peculiar mode of reasoning, which subject, with the contents of this section, will be treated under Ratios, Prime and Ultimate.

Section 2. On Centripetal Force. (1) Equal areas are described in equal times. Six corollaries on the comparison of velocities and forces; the former inversely as the perpendiculars on the tangents, the latter as the sagittæ of arcs described in equal times. (2) If equal areas be described in equal times about a centre, fixed or moving straightly and uniformly, the force is centripetal. Two corollaries and scholium. (3) In equiareal motion of a point about a moving centre, that point is acted on by a centripetal force, and by all the accelerating forces which act on the centre. Four corollaries and scholium. (4) In different circles uniformly described, force varies as $(\text{vel})^2 \div \text{rad}$. Nine corollaries and scholium indicating the deduction in the case of the planets. (5) Given the velocities in different parts of an orbit, to find the centre of force. (6) Centripetal force in the middle of a small arc is as sagitta $\div (\text{time})^2$. Five corollaries; various ways of comparing forces. (7) The orbit circular, centre anywhere within, to find the law of force. 3 Cor. (8) Ditto, ditto, where the forces act in parallel lines. Scholium; same considerations apply to other conic sections. (9) Law of force in equiangular spiral. Lemma 12 (the numbering of the lemmas runs on from the first section). Equality of parallelogram about conjugates in conic sections. (10) Law of force in ellipse about the centre. 2 Cor. and Schol.; extension to the parabola.

Section 3. Motion in conic sections about the focus. (11) Law of force in ellipse about focus. (12) Same for hyperbola. Lemma 13, Latus rectum in parabola always four times focal distance. Lemma 14, Perpendicular on tangent of parabola, mean between focal distances of point of contact and vertex. 3 Cor. (13) Law of force in parabola about focus. 2 Cor. (14) In conic sections about same focal centre, latera recta are in duplicate ratio of areas described. 1 Cor. (15) In ellipses, periodic times are in sesquiplicate ratio of major axes. 1 Cor. (16) And velocities are as perpendiculars on tangents inversely, and subduplicate ratio of latera recta directly. 9 Cor.; comparison of velocity in conic section and circle. (17) Given initial position and velocity, required conic section described. 4 Cor. and Schol.

Section 4. On finding conic sections from a given focus, and *Section* 5. On finding conic sections of which no focus is given. These sections, which carry on the lemmas from 15 to 27, both inclusive, and the propositions from (18) to (29), both inclusive, are entirely geometrical exercises in drawing conic sections through given points, or touching given straight lines, &c.: the results are hardly of use, even in the rest of the work, and a particular reference would now be of no use whatever, though the sections themselves are highly interesting to the geometrical inquirer.

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* This description is for reference, not for explanation, and is therefore very briefly given. To give an account of every corollary and scholium would have extended the article to a great length; hence only some of the more important of them are described. But the references to other articles in this work are for the elementary student. At the same time, a young student who can as much as understand the meaning of the terms will learn more about the Principia from this table of contents than from anything except the Principia itself.

Section 6. On finding the motion in a given orbit. (30) To find the place of a body in a parabola at the end of a given time. 3 Cor. Lemma 28. There is no oval figure whose area contained being any two radii, can be obtained by an equation in finite terms. [QUADRATURE OF THE CIRCLE.] 1 Cor.; relates to the ellipse. (31) To find the place of a body in an ellipse at the end of a given time. Scholium; approximate method.

Section 7. On rectilinear ascent and descent. (32) Required the space described in a given time by a body descending towards a centre.* Three cases, derived from the three conic sections. (33) Law of the velocity in the preceding, in the cases derived from the ellipse and hyperbola. 2 Cor. (34) The same in the case derived from the parabola. (35) An equable description of certain areas in the conic sections just alluded to takes place during the motion. (36) The time of the whole descent of a body from rest. (37) The time of the whole descent of a projected body. (38) Velocity and time determined in descent to a centre, the force being as the distance. 2 Cor. (39) Granting the quadrature of curves [QUADRATURE], and the law of force being any whatever, to determine the time and velocity at any point of a descent. 3 Cor.

Section 8. Determination of the orbit under any law of centripetal force. (40) The velocity at a given distance is always the same both in an orbit and a descent, if it be the same at any one distance in both. 2 Cor. (41) Granting the quadrature of curves, to find the orbit and the time of describing an arc, under any law of force. 3 Cor. (42) The same, the initial velocity and direction being given.

Section 9. On the motion of bodies in moveable orbits, and on the motion of the apsides. (43) How to make a body revolve equiareally in both a moving orbit and in the same fixed. (44) The difference of forces in the two cases is as the inverse cube of the distance. 6 Cor.; mostly exhibiting the conclusion in algebraical form. (45) To find the motion of the apsides in orbits nearly circular. 3 Examples; 2 Cor.

Section 10. On the motion of bodies in given surfaces, and on pendulous motions. (46) Given a plane, and a centre of force external to it, to find the motion of a point parallel to that plane, the law of force being any whatever. (47) The force in the last being as the distance, the orbit parallel to any plane must be an ellipse, and in all such ellipses the time of revolution is the same, and the same as that of a double ascent and descent. Schol. (48) and (49) Rectification of the epicycloid and hypocycloid. 3 Cor. (50) Way to make a body oscillate in a given hypocycloid. Cor. (51) If the force tending to the centre of the fixed circle in such an oscillation be as the distance, the times of all such oscillations are equal. Cor. (52) Determination of the velocity and time at any point of such an oscillation. 2 Cor.; the second being an application to the common cycloid. (53) On a given curve, to find the law of force which gives isochronous oscillations. 2 Cor. (54) A body moving on a rigid curve, under a given law of centripetal force, to find the time of its oscillations. (55) If a body move on a surface of revolution, the centre of force being in the axis, equal areas are described in equal times on a plane perpendicular to the axis. Cor. (56) To find the curve described in the last case.

Section 11. On the motion of bodies centripetally attracted to each other. (57) Two bodies, mutually attracting, describe similar figures about each other and about their common centre of gravity. (58) And with the same forces, the same curve may be described by either about the other at rest. 3 Cor. (59) Relation of the periodic times about the centre of gravity, and of one body about the other at rest. (60) In the same two cases, relation of the axes of the ellipses described. (61) And for any law of force, the bodies move round their centre of gravity as if a third body were placed in that centre, attracting with the same law of force. (62) Determination of the descent towards each other of two mutually attracting bodies. (63) Determination of the orbits of two such bodies, with given initial velocity and direction. (64) The force being as the distance, determination of the relative motions of several bodies. (65) The force being inversely as the square of the distance, and there being several bodies, one may move round another in an ellipse *nearly*, and describe areas nearly proportional to the times. 3 Cor. (66) The celebrated proposition of the three bodies, showing the diminution of the disturbance by the third body attracting both the others. (In the corollaries following, let the earth and moon, for distinctness sake, be the two bodies, and the sun the disturbing body: but let it be remembered that Newton does not mention the name of any planet nor hint at any application.) Cor. 1, If the earth had more satellites, the same proposition would apply to one as disturbed by the rest. Cor. 2 and 3, The moon moves quickest, cæteris paribus, in conjunction and opposition, and slowest in quadratures. Cor. 4, The moon's orbit is more curved in quadratures than in syzygies. Cor 5, Hence, excentricity being excluded, the moon is farther from the earth in quadratures than in syzygies. Cor. 6, Explanation of the effect of the variation of the sun's distance on the moon's period. Cor 7, The moon's apsides progress and regress, but the former more than the latter. Cor. 8, Effect of the position of the apsides with respect to the sun. Cor. 9, Effect on the excentricity of the moon's orbit. Cor. 10 and 11, Effect on the inclination and place of the nodes. Cor. 12, Disturbance rather greater in conjunction than in opposition. Cor. 13, The same species of effect produced whether the disturbing body is the greater or the less of the three. Cor. 14, 15, 16, 17, On the dependence of the disturbing forces on the distance of the disturbing body. Cor. 18, 19, 20, 21, 22, Explanation of precession of equinoxes and tides. (67) The disturbing body describes areas more nearly proportional to the times about the centre of gravity of the other two bodies than about either of them, and an orbit more nearly elliptic. (68) And the more so on account of its attracting the other bodies. Cor. (69) The attracting forces of bodies are, cæteris paribus, as their masses. 3 Cor. and Scholium.

Section 12. On the attractions of spherical bodies. (70) A particle placed inside a spherical shell is in equilibrium. (71) Spherical shells attract as if their whole masses were collected at their centres. (72) The attractions of spheres on points similarly placed with respect to them are as their diameters. 3 Cor. (73) At different internal points of a solid sphere the attractions are as the distances from the centre. Schol. (74) Solid spheres attract as if the whole masses were collected at their centres. 3 Cor. (75) The same of spheres attracting spheres. 4 Cor. (76) The same of spheres consisting of concentric layers of unequal density. 9 Cor. (77) The same is true when the forces of particles to each other are as their distances. (78) With the same law, the same is true of spheres consisting of concentric layers. Cor. and Schol.: Lemma 29. (79); (80) 4 Cor.; (81), 3 Exam.; (82): these show the method of finding the attraction of any sphere on a point without it, for any law of force. (83) The force being as the inverse nth power of the distance, to find the attraction of a segment of a sphere on a particle at its centre. (84) The same when the particle is not in the centre. Schol.

Section 13. On the attraction of non-spherical bodies. (85) If the attraction of the body on a contiguous particle be much greater than on one at a little distance, the attraction of the molecules of the attracting body diminishes in a higher ratio than the inverse square of the distance. (86) And the hypothesis of the last is a consequence, if the attraction of the molecules diminishes as the inverse cube of the distance, or faster. (87) If two similar bodies of the same material attract two molecules proportional to themselves and similarly placed, the attractions of the molecules on the two bodies will be proportional to their attractions on their similar particles similarly placed. 2 Cor. (88) If the particles of a body attract a molecule with forces as their distances, the whole attraction of the body will be towards its centre of gravity, and equal to that of a sphere equal to the body, and having its centre in that centre of gravity. Cor. (89) And the same if there be several bodies. Cor. (90) To determine the attraction of a circle on a point in its axis. 3 Cor. (91) To determine the attraction of a solid of revolution on a point in its axis. 3 Cor. relating to cylinders and spheroids. (92) Given an attracting body, to find (experimentally) the law of attraction of its particles. (93) If particles attract as the inverse nth power, a solid bounded by a plane, but indefinitely extended in all directions on one side of that plane, will attract an external particle with a force proportional to the inverse $(n-3)$rd power of the distance from that plane. 3 Cor. Schol.

Section 14. On the motion of particles from one medium into another. (94) If a particle pass through a medium contained between parallel planes, and be in its passage attracted to or repelled from the boundary of the medium it has left with a force depending on the distance from the boundary; the sine of the angle of emergence is always in a constant ratio to that of incidence. (95) And the velocity before incidence is to that after emergence as the sine of the angle of emergence to that of incidence. (96) And if the velocity must be greater before than after incidence, the angle of incidence may be made so great that the particle shall be reflected, and the angles of incidence and reflexion are equal. Scholium. (97) To give the boundary separating two media such a form that all particles issuing from one point may be refracted to another. 2 Cor. (98) To form a lens which shall have the property mentioned in the last. Scholium.

THE SECOND BOOK, mostly on resisted motion, contains 9 sections and 53 propositions.

Section 1. When the resistance is as the velocity. (1) The motion lost is as the space described. Cor. Lemma 1. (2) When no forces act but the resistance, the velocities at the beginnings of successive equal times are in geometrical progression, and the spaces described as the velocities. Cor. (3) To determine the resisted motion of ascent or descent when the force of gravity acts. 4 Cor. (4) The same when the particle is projected obliquely. 7 Cor. and Scholium, to the effect that the hypothesis is "magis mathematica quam naturalis."

Section 2. When the resistance is in the duplicate ratio of the velocity. (5) When no force acts, equal spaces are described in times which are in increasing geometrical progression, the velocities at the beginning of the times being in the inverse geometrical progression. 5 Cor. (6) Equal and homogeneous spheres, acted on by no forces, describe equal spaces in times which are reciprocally as their initial velocities, in which also they lose the same parts of their velocities.

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* The law of force, where not otherwise specified, is always as the inverse square of the distance.

(7) Also, in times which are as the first velocities directly and the first resistances inversely, they lose the same fractions of their velocities, and describe spaces jointly proportional to the times and the first velocities. 5 Cor. Lemma 2; which answers to finding the fluxions (called here momenta) of simple algebraical quantities. 3 Cor. and Scholium. [FLUXIONS.] (8) When a particle descends or ascends by gravity, the whole forces (gravity and resistance compounded) at the beginning of equal successive spaces, are in geometrical progression. 3 Cor. (9) Determination of the proportions of the times of ascent and descent in the last. 7 Cor. (10) The law of resistance being jointly as the density and the square of the velocity, required the law of density so that (gravity acting) a given curve may be described; as also the law of velocity. 2 Cor., followed by 4 Examp. and Schol., and also by 8 rules.

Section 3. When the resistance is partly as the velocity, partly as its square. (11) No force acting, and times being taken in arithmetical progression, the reciprocals of the velocities, increased by a certain constant quantity, will be in geometrical progression. 2 Cor. (12) But if spaces be taken in arithmetical progression, the velocities increased by a constant quantity will be in geometrical progression. 3 Cor. (13) Gravity acting, the relation between the time and velocity in the ascent or descent is shown. Cor. and Schol. (14) Relation connecting the space described with the preceding. Cor. and Schol.

Section 4. On spiral motion in a resisting medium. Lemma 3. A property of the equiangular spiral. (15) The density being inversely as the distance from the centre, and the centripetal force inversely as its square, the particle can revolve in an equiangular spiral. 9 Cor. (16) And, other things remaining, the same can be when the force is inversely as any power of the distance. 3 Cor. and Schol. (17) To find the force and law of resistance, by which a body may move in a given spiral, with a given law of velocity. (18) Given the law of force in the last, to find the density of the medium.

Section 5. On the density and compression of fluids, and on hydrostatics. Definition of a fluid. (19) A homogeneous fluid compressed in a close vessel (gravity, &c., apart) is everywhere equally pressed, and at rest. 7 Cases and Cor. (20) If a solid sphere form the nucleus of a fluid mass bounded by a concentric sphere, and the parts of the fluid gravitate equally to the centre at equal distances, the pressure sustained by the sphere is the weight of a cylinder which has the superfices for its base and the height of the incumbent fluid for its altitude. 9 Cor. (21) The density being proportional to the compression, and the centripetal force of particles inversely as their distance from the centre, then at distances in geometrical progression, the densities will be also in geometrical progression. Cor. (22) But if the force be inversely as $(\text{dist})^2$, then at distances in harmonical progression the densities will be in geometrical progression. Cor. and Schol. (23) If the particles of the fluid repel each other, the density is as the compression (and then only) when the repellent force of two particles is inversely as the distance of their centres. Scholium. (In consequence of the particles being supposed to repel only their nearest, Newton treats this only as a purely mathematical result.)

Section 6. On the resisted motion of pendulums.* (24) The quantity of matter in pendulums of the same length, is in a ratio compounded of their weights and of the duplicate ratio of their times of oscillation in vacuo. 7 Cor. (25) A pendulum which moves in a medium in which the resistances are as the *moments* of the times, and another moving unresisted in a medium of the same specific gravity, make their cycloidal oscillations in the same times, and describe proportional parts of their arcs together. Cor. (26) Resistance being as the velocity, cycloidal oscillations are isochronous. (27) Resistance being as the $(\text{velocity})^2$, the difference between the time of cycloidal oscillation in a resisting medium and a non-resisting one of the same specific gravity, will be very nearly as the arcs of oscillation. 2 Cor. (28) The resistances being as the moments of the time, the resistance is to the force of gravity as the excess of an arc of descent (cycloidal) over the subsequent arc of ascent to the square of the length of the pendulum. (29) Resistance being as $(\text{velocity})^2$, to find the resistance at any point of a cycloidal oscillation. 3 Cor. (30) Easier method of exhibiting the difference of an arc of descent and ascent. Cor. (31) If the resistance be altered in a given ratio, the difference of the arcs of ascent and descent is altered in the same ratio. Scholium Generale, containing many experimental results.

Section 7. On the motion of fluids and resistance of projectiles†. (32) Two systems of similar particles similarly placed, with given ratios between their densities, and beginning to move similarly in proportional times, will continue to do so, if there be no contact of particles except at instants of reflexion, and if there be no attracting forces of particles on one another but such as are as the diameters of corresponding particles inversely and the square of the velocities directly. 2 Cor. (33) And finite parts of these systems are resisted in a ratio compounded of the duplicate ratio of the velocities and diameters, and the ratio of the densities. 6 Cor. (34) The circular end of a cylinder encounters twice as much resistance as a sphere moving with the same velocity. Scholium, containing among other things the construction (without demonstration) of the solid of least resistance, which shows that Newton must have carried his fluxions (before 1687) far enough to solve some problems at least in what is now called the calculus of variations. (35) A medium consisting of equal particles at equal distances, to find the resistance it offers to a sphere. 7 Cor. and Schol. (36) To find the motion of water issuing through an orifice at the bottom of a cylinder. 10 Cor. Lemma 4. (37) Resistance to a cylinder moving in a non-elastic fluid. 3 Cor. and Schol. Lemma 5, 6, 7. A cylinder, sphere, or spheroid, of the same circular section, placed in a cylindrical canal of running water, or moving equally in it, is equally urged or resisted. Schol. (38) Resistance to a globe in a non-elastic fluid. 4 Cor. (39) The same when the globe is in a cylindrical canal. Schol. (40) The same, showing how to find the resistance experimentally. Scholium, containing accounts of fourteen experiments.

Section 8. On motion propagated through a fluid. (41) Pressure is not propagated through a fluid in right lines, unless when the particles lie in right lines. Cor. (42) Every motion propagated through a fluid diverges from the direct path. (43) Every tremulous body excites in an elastic medium pulses in every direction; but in a non-elastic medium, a circular motion. Cor. (44) 3 Cor. (45) Oscillations of water in a bent tube. (46) The velocity of waves. 2 Cor. (47) In pulses, the motion of the particles follow the law of an oscillating pendulum.* Cor. (48) The velocities of pulses in different media are as the square roots of the elastic force directly and the density inversely. 3 Cor. (49) Given the density and elasticity, to find the velocity. 2 Cor. (50) To find the length of the pulses. Scholium.

Section 9. On the circular motion of fluids. (Refutation of De Cartes's vortices on the hypothesis that the resistance which arises from the want of *lubricity* of the parts of a fluid, is proportional to the velocity with which the parts of the fluid are separated.) (51) If a cylinder of infinite length revolve about its axis in a uniform and infinite fluid, and create a vortical motion, the periodic times of the particles of fluid are as their distances from the axis. 6 Cor. (52) But if the revolving body be a sphere, these periodic times are as the squares of the distances from the centre. 11 Cor. and Schol. (53) A body revolving in a vortex so as to return to its place, must be of the same density as the parts of the vortex, and move in the same manner. 2 Cor. and Scholium, completing the refutation above mentioned.

THE THIRD BOOK, or application, styled 'De Systemate Mundi' contains forty-two propositions, and preliminaries. It is to be noted that it was the original intention of Newton that this book should be a popular one; and the original draft (so it is considered by Mr. Rigaud) was preserved, and was published in English, in 1728, under the title of 'The System of the World demonstrated in an Easy and Popular Manner by the illustrious Sir Isaac Newton;' and again in the original Latin. It is Opusculum XVII. in the collection of Castillioneus, who takes it from an edition published in 1731. It is not altogether popular, but, containing the mathematical propositions concerning comets to which Halley alludes in his letter, it may be the third book as it stood at the time when the idea of suppressing it was in Newton's mind. But we think that this work has been too easily admitted, and that its genuineness requires a searching discussion.

Regulæ philosophandi. 1. No more causes of natural things are to be admitted than are both true and sufficient to explain their phenomena. 2. The same causes are to be assigned to effects of the same kind, as far as that can be done. 3. Those qualities of bodies which can neither be strengthened nor weakened, and which belong to all bodies which are capable of being tried, are to be considered as universal qualities. 4. In experimental philosophy, all propositions collected by induction from phenomena are to be held either exactly or approximately true until other phenomena are found by which those propositions can be made either more accurate or subject to exception.

Phenomena. 1. The satellites of Jupiter describe areas proportional to their times about the planet, and their periodic times are in the sesquiplicate ratio of their distances from the planet. 2. The same is true of the satellites of Saturn (five then known). 3. The five primary planets, Mercury, Venus, Mars, Jupiter, and Saturn, revolve about the sun. 4. And their periodic times, and that of the earth about the sun, or the sun about the earth, the fixed stars being at rest, are in the sesquiplicate ratio of their mean distances from the sun. 5. And the primary planets are very far from describing equal areas in equal times about the earth; but do so about the sun. 6. The moon describes equal areas in equal times about the earth.

(1) The satellites of Jupiter are attracted to the planet by forces inversely as the squares of their distances. (2) The same of the primary planets about the sun. (3) The same of the moon about the earth. (4) The force which retains the moon in her orbit is the same force as that which, at the earth's surface, we call gravity. Schol. This is the celebrated test-proposition, the failure of which, in the first instance, made Newton lay his theory aside. (5) A similar result inferred as to satellites about their primaries, and primaries about the sun. 3 Cor. and Schol. (6) All bodies gravitate towards every planet; and gravitation towards every planet at a given distance from it, is as the mass of that planet. 5 Cor. (7) Attraction belongs to all

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* Some of these propositions would require explanation to make their meanings clear, which we have not here room to give.

† See preceding note.

* Lagrange has shown ('Misc. Taur.') that the method of Newton here only leads to a concealed identity, which proves nothing.

bodies, and is proportional to the quantity of matter in them. 2 Cor. (8) If each of two globes be everywhere of one density at one distance from the centre, the attraction of each on the other is inversely as the square of the distance of their centres. Cor. 4. (9) In descending to the centre of a planet, gravity diminishes as the distance from that centre. (10) The motion of the planets can continue for an immensely long time.

Hypothesis 1. The centre of the solar system is at rest. (Newton takes the universally admitted hypothesis, and shows what the long disputed centre of the system is.) (11) The centre of gravity of the whole system is at rest. (12) The sun is perpetually in motion, but never far from the centre of gravity of the whole. Cor. (13) The planets move in ellipses, having their focus in the sun's centre, and they describe equal areas in equal times about that focus. (14) The nodes and aphelia of the planets are at rest: 2 Cor. and Schol. modifying the proposition by considerations of perturbation. (15) To find the axes of the orbits. (16) To find the eccentricities and aphelia. (17) The diurnal motion of the planets is uniform, and the libration of the moon arises from the diurnal motion. (18) The figures of the planets are oblate. (19) To find the proportions of the axis of a planet. (20) To compare the weights of bodies at different parts of the earth. (21) The equinoctial points must regress, and the axis of the earth must have a nutation twice in each year. (22) All the lunar motions and inequalities follow from the preceding principles. (23) The inequalities of other satellites may be derived from those of the moon. (24) The tides of the sea arise from the actions of the sun and moon. (The Jesuits' edition inserts in this place the treatises of Daniel Bernoulli, Maclaurin, and Euler, on the tides.) (25) To find the disturbing force of the sun upon the moon. (26) To find the horary increment of the moon's area about the earth. (27) From the moon's horary motion to find its distance from the earth. 2 Cor. (28) To find the diameters of the orbit in which the moon would move, but for excentricity. (29) To find the variation of the moon. (30) To find the horary motion of the moon's nodes in a circular orbit. 2 Cor. To find the horary motion of the moon's nodes in an elliptic orbit. Cor. (32) To find the mean motion of the moon's nodes. (33) To find the true motion of the moon's nodes. Cor. (Newton, in the third edition, here adds Machin's method of finding the motion of the moon's nodes.) (34) To find the horary variation of the moon's inclination. 4 Cor. (35) To find the moon's inclination at a given time. Schol. giving an account of several other peculiarities of the lunar motions, and completing the lunar theory. (36) To find the force of the sun upon the sea. Cor. (37) The same for the moon. 10 Cor. (38) To find the figure of the moon. Cor. Lemma, 1, 2, 3. On the effect of a ring of matter at the equator, disturbed by the sun, upon the earth's rotation. *Hypothesis* 2.[*] The effect of such a ring in causing precession is the same whether the ring be fluid or solid. (39) To find the precession of the equinoxes. Lemma 4. Comets are above the moon, and in the planetary regions. 3 Cor. (40) Comets revolve in conic sections, having the sun in a focus, and describe equal areas in equal times. 4 Cor. Lemma 5. To find a curve of the parabolic kind, which shall pass through any number of given points. Cor. Lemma 6. From any given places of a comet to find its place at any intermediate time. Lemmas 7, 8, 9, 10, 11. On the parabola, preparatory to the next propositions. (41) To find the parabolic orbit of a comet, from three observations. Example, the comet of 1680, from various observations, and a long discussion of the physical characters of comets. (42) To correct the orbit of a comet; with other examples and discussions. It is to be understood that throughout this third book continual comparison with observation occurs, which it is unnecessary to repeat as to each particular case, since the purpose of the book itself is the comparison of the results of theory with observation.

The 'Scholium Generale,' at the end of the Principia, has been so often quoted, alluded to, attacked, or brought forward as Newton's final explanation of the metaphysics (if that be a proper word) of his system, that even as a matter of reference we may be justified in translating it entire. It is not found in the first edition. Two notes, as marked, are Newton's.

"The hypothesis of vortices is encumbered with many difficulties. Since a planet's radius describes areas proportional to the times, the periods of the parts of the vortex should be in the duplicate ratio of their distances from the sun. And since the planets' periods are in the sesquiplicate ratio of their distances, the periods of the parts of the vortex should also be in that ratio. Since the minor vortices about Jupiter, Saturn, &c., preserve their rotation, and swim quietly in the vortex of the sun, the periodic times of the parts of the solar vortex should be equal. The revolutions of the sun and planets about their axes, which should agree with the motions of the vortices, differ from all these proportions. The motion of comets is highly regular, follows the same laws as that of the planets, and cannot be explained by vortices. They are carried most excentrically to all parts of the heavens, which could not be unless the vortices were removed.

"Projectiles, in our atmosphere, feel only the resistance of the air; take that away, as in Boyle's vacuum, and the resistance ceases, since the light feather and the solid gold fall with the same velocity in this vacuum. And such is the case in the celestial spaces which are above the atmosphere of the earth. All bodies in those spaces must move perfectly freely; and hence the planets move perpetually, according to the laws explained, in orbits of given form and position. They will persevere in their orbits by the laws of gravity; but they could by no means originally have taken that regular orbital path by the same laws.

"The six principal planets revolve about the sun in circles concentric with the sun, in the same direction, and very nearly in the same plane. The ten moons revolve about the earth, Jupiter, and Saturn, in concentric circles, in the same direction, and very nearly in the plane of their planets' orbits. And all these regular motions have no origin in mechanical causes[*]; for the comets are freely carried in very excentric orbits, and through all parts of the heavens. By such motion comets pass freely and easily through the planetary orbits, and in their aphelia, where they move more slowly and remain longer, they are very distant from each other, and attract each other very little. This most elegant group of sun, planets, and comets can only arise from the design and government of a powerful and intelligent being. And if the fixed stars be centres of like systems, all these constructions of a similar design must be under the dominion of one being: the more since the light of the fixed stars is of the same nature as that of the sun, and all the systems give light to each other. And that the systems of the fixed stars may not fall into each other, he has placed them at immense distances from each other.

"He rules all things, not as the soul of the world, but as the lord of all things. And from his dominion, God the Ruler is often called *Παντοκράτωρ*. For God is a relative term, which refers to his servants; and deity is the rule of God, not over his own body, as those think who call him the soul of the world, but over his servants. The most high God is a being eternal, infinite, absolutely perfect; but a being however perfect, without dominion, is not God the Ruler. For we say, my God, your God, the God of Israel, the God of gods, the Ruler of rulers; but we do not say, my eternal one, your eternal one, the eternal one of Israel, the eternal one of gods; we do not say, my infinite one, or my perfect one. These appellations have no relation to servants. The word God always[†] signifies ruler; but every ruler is not God. The rule of a spiritual being makes him God, true rule a true god, the highest rule the highest god, a feigned rule a feigned god. And from the reality of his dominion it follows that the true God has life, intellect, and power; and from his other perfections, that he is the highest or most perfect being. The Eternal is infinite, omnipotent, and omniscient; that is, endures from eternity to eternity, and is present from infinity to infinity; he rules all and knows all that is or can be. He is not eternity nor infinity, but eternal and infinite; he is not time nor space, but endures and is present. He endures for ever, and is everywhere present; and by his universal existence, both in time and space, he is the creator[‡] of time and space. Since any particle of space always is, and also some one indivisible moment of duration, certainly the framer and ruler of all things can never be nonexistent at any time or in any place. Every thinking soul is, at different times, and in its different organs of sense or motion, the same indivisible person. There are parts of time successive, and parts of space co-existing; but neither in the person of man, that is, in his thinking principle, and much less in the thinking substance of God. Every man, considered as a sentient existence, is one and the same man throughout his whole life, and in every one of his organs of perception. God is one and the same God always and everywhere. He is omnipresent, not only virtually but substantially; for the first without the second cannot be. In him[§] all things are contained and moved, but without mutual effect from each other. God no way feels the motion of bodies: they feel no resistance from the omnipresence of God. All men confess that the most high God exists necessarily, and by the same necessity always and everywhere. Whence also he is throughout alike, all eye, all ear, all brain, all arm, all thought, understanding and action, not in the human or corporeal manner, but in one altogether unknown. As a blind man has no idea of colour, so we have no idea of the modes in which the all-wise God perceives and understands all things. He is altogether without body or figure, and thence can neither be seen, heard, touched, nor worshipped under the likeness of any corporeal thing. We have ideas of his attributes, but we know nothing of the substance of any thing. We see only the figures and colours of bodies, we hear only sounds, we touch only external surface, we smell only odours, and taste tastes: we can perceive the inmost substance by no sense, by no reflected action; much less can we have an idea of the substance of God. Him we know only by his properties and attributes, and by the most wise and excellent structure and final causes of things; and we wonder at him for his perfections, but we venerate and worship him for his dominion. We worship him as servants, and a God without dominion, providence, and final causes is nothing else but fate and nature. From a blind metaphysical necessity, which is certainly the same always and everywhere, no variation of things can arise. Every diversity of created things in space and in time can only arise from the ideas and the will of a necessarily existing being. But God is said allegorically to see, hear, speak, laugh, love, hate, desire, give, receive, rejoice, be made angry, fight, work, build, and construct. For every expression concerning God is drawn from human affairs by a certain figure of similitude, not perfect indeed, but something like. And this much of God, of whom it certainly belongs to natural philosophy to treat from phenomena.

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[*] In the first edition this is a lemma, which probably appeared to Newton to need no proof, as none is given. In the third it is, as we see, made an assumption. Laplace has confirmed it, by showing that the precession and nutation would remain unaltered, if the whole sea were at any one moment to be solidified without alteration of its specific gravity.

[*] By *causa mechanica* Newton means a material machinery, such as the solid orbs of some of the Ptolemaists.

[†] "Our countryman Pocock derives the word Deus from the Arabic *du* (sometimes *di*), which means ruler. And in this sense the princes are called gods, Psalms, lxxxiv. 6, and John x. 45. And Moses is called God of his brother Aaron, and of king Pharaoh, Exodus iv. 16, and vii. 1. And in the same sense the souls of departed princes were called gods by Gentile nations, but falsely from want of dominion." (Author's note.)

[‡] "Et existendo semper et ubique durationem et spatium *constituit.*"

[§] "So thought the ancients, as Pythagoras (Cic., 'De Nat. Deor.,' lib. i.); Thales; Anaxagoras; Virgil ('Georgics,' iv. 220, 'Æn.,' vi. 721); Philo ('Allegor.,' lib. i. sub init.); Aratus ('Phœn.,' sub init.). So also the sacred writers, as Paul, Acts xvii. 27, 28; John, Gospel, xiv. 2; Moses, Deut. iv. 39, and x. 4; David, Psalms, cxxxix. 7, 8, 9; Solomon, 1 King sviii. 27; Job, xxii. 12, 13, 14, Jeremiah, xxiii. 23, 24. The idolators falsely imagined the sun, moon, and stars, the souls of men, and other parts of the universe to be parts of the most high God, and therefore to be worshipped." (Author's note.)

"So far I have explained the phenomena of our heavens and the sea by the force of gravity: but I have not yet assigned the cause of gravity. Certainly this force arises from some cause, which penetrates even to the centre of the sun and planets, without diminution of its virtue; and which acts not according to the superficial magnitude of particles (as do many mechanical causes), but according to the quantity of solid matter; and of which the action is extended in every direction to immense distances, diminishing always in the duplicate ratio of the distances. Gravity towards the sun is compounded of the gravity towards all the several particles of the sun, and in receding from the sun diminishes accurately in the duplicate ratio of the distances, as far as the orbit of Saturn, as is made manifest by the quiescence of the aphelia of the planets, and even as far as the aphelia of the comets, if they also do not move. But I have not yet been able to deduce the reason of these properties of gravity from phenomena, and I do not frame hypotheses. For whatever is not deduced from phenomena, is to be called *hypothesis:* and hypotheses, whether metaphysical or physical, or of occult qualities, or mechanical, have no place in *experimental philosophy*. In this philosophy propositions are deduced from phenomena, and are rendered general by induction. So impenetrability, mobility, the impetus of bodies, and the laws of motion and gravity have become known. And it is enough that gravity really exists and acts according to laws explained by me, and suffices for all the motions of the heavenly bodies and of our sea.

"I might add something on that most subtile spirit which pervades solid bodies and lies hidden in them, by the force and action of which the particles of bodies attract each other at the smallest distances, and adhere when contiguous: and by which electric bodies act at greater distances, both by attracting and repelling neighbouring particles; and by which light is emitted, reflected, refracted, inflected, and gives heat to bodies; and by which all sensation is excited, and the limbs of animals are moved at pleasure, namely, by its vibrations through the solid capillaments of the nerves, propagated from the external organs of sense to the brain, and from the brain to the muscles. But this could not be explained in few words; nor is there a sufficient quantity of experiments to show and determine the laws according to which this *spiritus* acts."

There is not a sentence of the preceding scholium which has not a direct reference to some common opinion, at home or abroad, of the physics, metaphysics, or theology of Newton's system. He had probably seen and heard enough, in the interval between the editions, to teach him on what points explanation was desirable; certain it is, that there is hardly an objector since his time who might not have found himself already answered, if he had read this scholium with candour and attention.

The commentators of Newton have one and all, as might be supposed, treated their author as a source of elementary instruction, to be explained and cleared from the effects of that brevity and obscurity (the latter more than due to the former) which the Principia almost everywhere presents. But the time has arrived when this work is hardly in the beginner's course, though it may be recommended to him, when he has studied the modern analysis, to make himself acquainted with its methods until he has caught their spirit. What we now want is rather an historical commentary, which shall put the student in possession of the modes of reasoning peculiar to Newton's predecessors, shall point out how the Principia came to have its form, and shall place him, so far as is possible, in the midst of that atmosphere of remnants of the old philosophy and aspirations after the new, in which the mind of Newton gained its growth.

In 1730, Dr. John Clarke published 'A Demonstration of some of the principal sections of Sir I. Newton's Principles,' &c. This work contains the greater part of the first book somewhat expanded, and with the applications of the third book intermixed. But it omits the most important part of the eleventh section: nevertheless, a student who should join with Dr. Clarke's work the article GRAVITATION in the present one, would have the most important parts of the Principia, so far as is necessary to gain an insight into Newton's methods.

In the same year, 1730, George Peter Domck published his 'Philos. Math. Newt. Illustratæ Tomi Duo, Londini.' (This work is sometimes wrongly called an edition of the Principia, and its author's name is sometimes spelled Donick.) The first volume of it is only a preparatory course of mathematics; the second gives a large part of the first book in Newton's manner, and gives more of the results of the eleventh section. It also enters upon some of the numerical applications of the third book.

The Commentary of the Minims (Jesuits they are usually but wrongly called) Le Sueur and Jacquier (1739) is an excellent performance for its time, considered as attempting to smooth the details of the mathematical difficulties. It uses algebra freely, but is totally insufficient to show the use of the differential calculus as now known; but it very frequently developes satisfactorily a point at which Newton only hinted.

Emerson's 'Short Comment on Newton's Principia,' 1770, is a brief explanation of some of the mathematical difficulties and obscurities, followed by defences of the Principia, the Optics, and the Chronology. Emerson defended everything of Newton's.

The popular explanations of Maclaurin, Pemberton, and Voltaire are too widely known to need description; they do not much help the mathematical student. Many so-called explanations of Newtonian philosophy (such as Benjamin Martin's, 1751) are literally nothing but treatises on general physics.

The additions to Madame du Chastellet's translation consist of a popular *résumé* and the mathematical treatment of various questions of the Principia. The latter must be considered as emanating from Clairaut, since they were his lessons to his pupil. Some have supposed that Voltaire's work belongs in the same sense to Madame du Chastellet.

In the 'Mécanique Céleste,' book 16, cap. 2, Laplace has exhibited the results of Newton's lunar theory, and connected them with the modern analysis of the subject to a certain extent. The preciseness of the manner of compressing Newton's results renders this chapter valuable, and likely to assist the student of the Principia.

Mr. Airy's development and extension of the results of the eleventh section (which forms the article GRAVITATION in this work) places one of the methods of the Principia, and one which ought to last, within the reach of every student. It is unique, the difficulties of the eleventh section having left it almost without a commentator, and altogether without an explainer; and it takes in several of the discoveries of the present time.

Many commentaries on the Principia have been written at Cambridge by private tutors for the use of their pupils, of which some have been printed. Of the following we have never seen more than the title: 'Excerpta quadam e Princ. Phil. Nat., cum notis variorum,' Cambridge, 1765. There is Carr's three sections of Newton, a modern work, and an exposition of various parts of the Principia contained in the second edition of Professor Whewell's 'Dynamics.' We believe that several recent Cambridge works contain some help on the subject.

To give a view of the foreign objections to Newton's system, at the time of its first introduction, the following works may serve: 1, 'Collection of Papers which passed between Mr. Leibnitz and Dr. Clarke, in 1715 and 1716,' by Dr. Samuel Clarke; London, 1717. 2, 'Traité de Paix entre Des Cartes et Newton,' by the Jesuit Aimé-Henri-Paulian; Avignon, 1763. 3, 'Le vrai Système de Physique générale de M. Isaac Newton, exposé et analysé en parallele avec celui de Des Cartes,' by the Jesuit Louis Castel; Paris, 1743 (a defence of Descartes). 4, 'Anti-Newtonianismus,' by Celestini Cominale, M.D.; Naples, 1754. 5, 'Discours sur les différentes Figures des Astres,' by Maupertuis, the first assertor of Newton's doctrines in France; Paris, 1732, and in the collection of his works. 6, 'Letters to a German Princess,' by Euler (first published in 1770, translated into English by Dr. H. Hunter, 1795).

The most celebrated comments in the way of objection are those of LEIBNITZ, JOHN BERNOULLI, and HUYGHENS [see BIOG. DIV.]; the first and third real admirers of the genius of Newton, the second also an admirer after his fashion. Many of their remarks may be found in the published correspondence of the first two, but the history of the effect produced by the Principia in the years following its publication is scattered in too many places for us to attempt to give the particular publications which should be consulted.

PRINCIPLE, D'ALEMBERT'S. [FORCES, IMPRESSED AND EFFECTIVE; VIRTUAL VELOCITIES.]

PRINTING, in the widest sense of the word, may be defined to be the art of producing copies of any writing or other marks by pressure, either upon a substance so soft as (like wax or clay) to take the shape, whether in relief or by indentation, of the stamp applied to it, and yet not so perfectly fluid (like water) as to refuse to retain the form so given to it; or upon a substance sufficiently bibulous or otherwise attractive as to receive colour from some pigment with which the stamp is daubed. The essence of printing is the production of a copy by pressure. Correctly speaking, however, it is not an exact copy or fac-simile which printing produces in any case; so far from that, wherever the surface is raised in the stamp, it is sunk in the impression, and *vice versâ*, and even a merely coloured mark is always reversed in form; but, what is alone of importance, all the impressions are exact copies of one another, and also bear a certain and perfectly assignable relation to the stamp or type.

Even on a theoretical view of the subject, printing by means of merely a variegated surface or stamp, or, in other words, the reproduction, in soft substances, of cameos and intaglios, would seem to be the simpler and more obvious of the two kinds of printing we have mentioned. This may be said to be printing by pressure alone. In the other kind of printing, by the transference of colour, there is required the introduction, in addition to the type and its recipient, of a third element or agent, namely, the colour to be transferred. And this was an addition very little likely ever to be made until the idea of multiplying copies of coloured marks had itself occurred, that is, until the very object had been thought of which this was the only means of accomplishing, and which was the only object this process was suited to accomplish. Having a seal or cut stamp in his hand, the making an impression with that upon wax or any other soft substance was extremely natural for a person wishing on any occasion to leave his mark or sign; it was the same thing, in fact, with notching a piece of wood or stone with a knife or other sharp instrument, with this difference only, that the knife makes its marks by excision, or altogether removing and abstracting part of the substance operated upon; the stamp, by extrusion, or merely pushing it aside. Or still more nearly it resembles the rudest and readiest of all ways of making a mark, namely, by dealing a blow. But it is a mode of making a mark only; that is its sole purpose and object. There is no thought, so long as this kind of printing exclusively is used, of multiplying copies of the same mark; that is an idea far removed from the first and most natural employment of a dry stamp or seal, and not perhaps more likely to be suggested by such stamping or sealing (although capable of being so realised) than by some other things—by the mere common process, for instance, of copying by imitation. If a transcriber had ever had before him a written page, with the ink not yet dry, which he was laboriously reproducing with his pen, the slowness of his procedure, especially if he were pursued by an active and growing demand on the part of the public for books, might have led him to the thought of the possibility of performing the whole task in a manner at once, by merely impressing the wet writing upon the blank paper, and then re-transferring it from the reversed copy thus made to another sheet, in order to recover the original position of the characters. And if by any means the reversed copy could be kept moist, or its moisture repeatedly renewed, here was a method of procuring in the same easy manner an indefinite number of copies. The mechanical facilities were still to be invented, but this was the elementary idea of what we have been regarding as the second kind of printing; which, it thus appears to us, would probably not be suggested by the first kind at all, but rather by the desire of effecting an object (namely, the multiplying of copies) altogether different from that (namely, the mere making of a mark) which was the primary purpose of a dry stamp or seal, and only presenting itself at a much later and more advanced stage in the progress of civilisation.

These considerations may help to account for the historic fact that the use of engraved seals for impressing soft substances preceded by so many centuries the invention of the art of printing by the transference of a pigment, or, in other words, by means of coloured stamps or types. Nevertheless the principle of an engraved or uneven surface might still for a particular purpose be called in to the aid of the process of pigment-printing, although it had nothing to do with the suggesting of that process. Suppose the writing which is to be transferred by such mode of printing to be traced in visible black characters upon a smooth surface of wood or metal, how is the pigment to be most conveniently renewed every time it gets dry or faint? With an even surface it is evident that this could only be done by the tedious method of retracing every line of the writing with a pen or brush, a method which—besides its consumption of time, making printing, in fact, as slow as writing—would probably be found to be inefficient, as leaving the page dry or half dry in one part before it could be inked over in another. But by either cutting hollows for the ink, or causing the characters to stand out in relief, the great advantage is gained of being able to spread the pigment by a few sweeps of the brush along every line which it ought to colour, without leaving any of it upon the intervening parts of the wood or metal: in the case of hollow lines being cut (as in copperplate-printing), the ink that is spread in the first instance over the whole surface is easily wiped away from the rest without being taken out of the hollows.

At this point, then, we may be said to have at last obtained the art of printing in a practical shape. The art was now invented. This is precisely the art of printing as it has been known in China since the middle of the 10th century, when it is said to have been discovered by a minister of state named Foong-taon, and as it is still practised there. The page of writing to be multiplied is pasted down upon the smooth surface of a prepared block, commonly of pear-tree, on which it leaves an impression of the characters in an inverted form, and then the block thus marked is made ready to be printed from, by cuting away all the blank parts of the face of the wood, and the lines forming the characters are thus left in relief, so as alone to receive the ink every time the brush is applied.

In such a language as the Chinese, which is without an alphabet, or at least in which the elementary characters have not [illegible]een reduced to the same limited and commodious number as in most [illegible]ther languages, by making them represent sounds instead of ideas or [illegible]ings, this, or the lithographic process, are the only kinds of printin[illegible] at are generally applicable. The subsequent improvements or exten[illegible] of the principle are all dependent upon the common alphabetic m[illegible] of writing.

Even in Europe, however, although the mode [illegible]riting was alphabetic, it was the Chinese mode of printing th[illegible] as first practised. Some have even supposed that the knowledge [illegible]e art was originally obtained from the Chinese; and indeed, beside[illegible] at other less direct communication there may have been, Marco [illegible], who returned from China about the end of the 13th century, h[illegible]n and described at least one application of the invention in th[illegible]try, the fabrication of a species of paper-money by stamping it with a seal covered with cinnabar (vermilion). But, as far as we can trace, it was not till fully a century after this that even this simplest kind of printing began to be practised in Europe. It appears to have been first applied to the fabrication of playing-cards and manuals of popular devotion, the latter for the most part consisting, like the cards, of merely a single page, though in some instances assuming the form of little books of several pages. It is believed that about the year 1400, or soon after, both these articles, which had previously been manufactured by hand, and each copy of course by a separate operation, began to be multiplied, like the Chinese paper-money, from engraved blocks or stamps. There is no record of this innovation, but the fact is inferred from the perfect similarity of several copies of the same page, which could only have been produced by their having all been impressions from a common original. The playing-cards thus fabricated are merely pictures; but many of the devotional manuals, besides pictures, which in these also fill the greater part of each page, present short texts from Scripture, and other examples of engraved letters and words. It is evident, however, that the essence of the new art is as much in the pictures as in the legends, which are only pictures of another kind.

The æra of these block prints and books, as they are called, may be stated to be the first half of the 15th century: one in Lord Spencer's collection bears the date of 1423, and there is reason to believe that other specimens were executed almost as late as 1450. Of the block-books of any considerable magnitude the two most remarkable are, that generally styled, though probably not correctly, the 'Biblia Pauperum,' a small folio of forty leaves, each containing a picture, with a text of scripture or some other illustrative sentence under it, the first edition of which (for there were several), is supposed to have been produced between 1430 and 1450, and of this an early edition is in the King's Library of the British Museum; and the 'Speculum Humanæ Salvationis,' consisting of sixty-three leaves of the same small folio size, containing in all fifty-eight pictures, with two lines of Latin rhyme under each. With regard to this last in particular, however, there has been a great deal of disputation, some denying altogether its claim to be reckoned a specimen of block-printing, in so far as the legends are concerned; but it is now generally admitted that at least some of the legends have every appearance of having been printed from the same block with the picture, although in other cases they seem to have been subsequently inserted from moveable types. A minute examination of the cuts, undertaken by Mr. Ottley, has proved that the Latin edition with moveable types was undoubtedly the earliest, and dates probably about 1470. The edition in which twenty of the subjects have the inscriptions cut on the wood, while the others are from moveable types, is apparently a copy ("laid down," as engravers style it) of the original Latin edition. Another block-book that was frequently printed, and which is noticeable as consisting wholly of text, without pictures, was the small Latin Grammar of Donatus, the common school-book of those days. These block-books are, like the Chinese books at this day, printed only on one side of the leaf, and may have been produced in Germany.

At this point, as we have already observed, printing would have stopped, if the art of alphabetic writing had remained undiscovered. At most, the art could not have been carried beyond what has been called logography, or the printing with types, each containing a whole word, a method which is in partial use in China, and has even in recent times been attempted among ourselves, but which is manifestly of very limited application. Logography, indeed, is merely a modification of block-printing; the principle is the same whether the block or type contain a whole word, a whole line, a whole sentence, or a whole page.

It is not unlikely, however, that the partial employment of logography in the infancy of European printing may have been what suggested alphabetic printing. There is good evidence that some words of common occurrence were early cut out on separate stamps or types; and although this may have been done only after the invention of alphabetic printing, to save the trouble of composition (or setting up the words from the letters), it is possible that the same thing may also have been done while only block-printing was known, with the view of saving the repeated cutting out of the same words. If so, the perception, thus awakened and turned to account, of the fact that two different pages often contained some words in common, would be apt, it may be thought, to conduct to the reflection that all words and all pages that could be printed were composed out of the same twenty-four letters, and that therefore if a sufficient number of types consisting each of a single letter could be provided, the same types that had been made use of in printing any one page might, with the mere trouble of re-arrangement, be made to serve for printing any other. Here was what we may call quite a new principle. Logography was indeed the employment to a certain extent of moveable types; but the principle of moveable type printing was no more there than we can say the principle of alphabetic writing is to be found in the 214 radical characters of the Chinese. The universality which is the essence of a principle is equally wanting in both cases.

Yet, whether it may have been arrived at through the medium of logography or not, it may be safely affirmed that, where alphabetic writing was known, alphabetic printing could not be long in being found out. It was in fact, in a manner, already invented, in the coexistence of pigment printing on the one hand, and of alphabetic writing on the other; for it was the mere resultant, without the assistance of any third element, of the combination of these two ideas. Not that even this simple combination would of necessity be immediately made; the history of discovery sufficiently attests that it will often be a considerable time before a third thing is thought of which would be at once accomplished by the mere bringing together, and into simultaneous and accordant action, of two things already familiarly known and practised; but still, fortuitously, or through reflection and experiment, the new idea is much more likely to be struck out in these circumstances than if a more complex combination were required to produce it, and, especially where the state of society supplies any considerable stimulus to the attainment of it, cannot be very long in being arrived at.

The common art of printing, in essentially the same degree of completeness in which we now possess it, had certainly been discovered before the middle of the 15th century; but when, where, and by whom each successive improvement of the original pigment-printing by means of engraved blocks was discovered and first put in practice is not so easily settled. The employment of moveable types, the production of such types by the process of casting them in metal, and the formation of the matrix, or mould, by means of the punch, or stamp of hardened steel by which the matrix is impressed or hollowed out; these, disregarding mere mechanical facilitations, may be considered as the three great organic changes by which block-printing was transformed into the art as it now exists. They are far, indeed, from being upon a level in point of importance; they descend in value in the order in which we have enumerated them, which must also have been the order in which they followed each other; and the third contributes so little to the completion of the invention, as compared with either the first or second, that we might perhaps without much injustice omit it altogether. Pigment stamping, the breaking up of the block-page into single letters, the substitution of letters of cast metal for those of cut wood, and the production of many matrices from one punch, the four successive steps constituting the invention of printing, have thus all one end and aim. This very circumstance might enable one of them in a great measure to suggest the next.

Simple as the first of the four successive discoveries—stamping or printing with a pigment—may be thought, it was perhaps both the most important and the most difficult to achieve of the whole. As for the three subsequent improvements, which constitute the whole portion of the art of printing indisputably invented in Europe in the 15th century, and to which alone the claims of the several individuals to whom the invention has been attributed have any reference, even the chief of them, the substitution of types containing each a single letter for blocks containing an entire page, must, we apprehend, be considered as inferior to the primary Chinese discovery in novelty, or real originality of conception, as it undoubtedly is in importance. That wonderful instrument, the alphabet, being already invented, this improvement consisted merely in chopping down the engraved wooden block into as many separate pieces as there were letters cut upon it. The casting of metal types again was only an application of the art of founding, which is one of the most ancient of the arts practised by men; and the fabrication of the matrix by a punch was merely an example of the familiar practice of receiving the impression of a stamp or seal upon a substance softer than itself, and precisely the same thing with the very common mode of stamping coins by hammering.

Four names have principally figured in the controversy that has been raised about the invention of printing:—JOHN GUTENBERG (paternally Gänsfleisch), of Strasburg; JOHN FUST (or Faust), of Mainz; PETER SCHÖFFER (in Latin, Opilio), of Gernsheim; and LAWRENCE KOSTER (or Janszoon), of Haarlem. Of all these, and of their claims to the invention, accounts will be found in the BIOGRAPHICAL DIVISION under their respective names.

An ancient chronicle, first printed at Cologne in 1499 ('Chronica, sive Fasciculus Temporum,' &c., commonly called the 'Cologne Chronicle'), notes that, after ten years had been spent in preparation, the art of printing began to be practised (cœptum est imprimi) in the year 1450. The knowledge of the art was first made public and carried into other countries by the dispersion of many of the workmen on the storming of Mainz by Adolphus of Nassau, in 1462. Printing was first practised in Italy, in the town of Subiaco, in the Roman territory, in 1465; in France, at Paris, in 1469; in England, at Westminster, in 1474; and in Spain, at Barcelona, in 1475. It is said that by the year 15 0 there were already about 200 printing-presses in Europe.

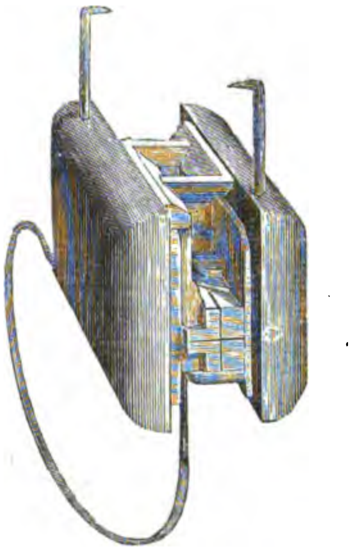
The following works relating to the invention of printing may be consulted with advantage: H. Junius, 'Batavia,' 1558, which contains the claim for Koster; P. Marchand, 'Histoire de l'Origine et des Progrès de l'Imprimerie,' 1719-41; P. S. Fournier, 'Dissertation sur l'Origine de l'Imprimerie,' 1759; M. Maittaire, 'Annales Typographicæ,' 1760; Jo. Dan. Schöpflin, 'Vindiciæ Typographicæ,' 1760; Baron Heineken, 'Idée Générale d'une Collection complète d'Estampes,' 1771; G. Fisher, 'Typographische Seltenheiten,' 1804; Singer, 'Researches into the History of Playing-Cards, with Illustrations on the Origin of Printing and Engraving on Wood,' 1816; W. Ottley, 'History of Engraving upon Copper and on Wood,' 1816; Dahl, 'Die Buchdruckerkunst erfunden von J. Gutenberg, verbessert und zu Vollkommenheit gebracht durch P. Schöffer,' 1832; Jackson and Chatto, 'Treatise on Wood Engraving,' 1839; C. Knight, chiefly with reference to the introduction of printing into England, 'The Old Printer and the Modern Press,' 1854; and W. L. Sotheby's costly work on 'Early Block Books,' 1859.

Of the important effects produced by this great discovery, and of the progress made in civilisation by the diffusion of books, it is not our province to treat here. We proceed to describe the mechanical processes connected with printing. For very many years these processes received few improvements; but from about the commencement of the present century they have been numerous and important. We shall therefore treat of them in the order in which they may be said to occur in their uses in a modern printing-office. These are *Type-founding; Composing; Printing Presses and Printing Machines;* and *Stereotyping.* To these as connate subjects we shall add *Printing for the Blind; Nature Printing* or *Autotypography;* and *Printing by Collins's Patent Process.*

Type-founding.—After the invention of Schöffer, the apparatus employed appears, at a very early period, to have assumed its present form. The first satisfactory evidence upon this point is afforded by the device of Badius Ascensius, an eminent printer of Paris and Lyons, at the beginning of the 16th century; which device was subsequently adopted, with various modifications, by several other printers, among whom was an English practitioner, Anthony Scoloker, of Ipswich. It exhibits the various operations then usually carried on at a printing-office, embracing type-founding as well as composing and printing; and it represents the matrix and other apparatus of the type-founder in the form still used. Most of the early printers, in England as well as on the Continent, cut and cast their own types; and Aldus Manuzio, towards the end of the 15th century, distinguished himself by the elegance of his type, and invented that now called italic. [MANUZIO, ALDO, in BIOG. DIV.] One of the earliest notices of that division of labour which has tended so greatly to the improvement of the art, is found in a decree of the Star Chamber, dated July 11, 1637, intended to suppress or render more difficult the publication of seditious works by the Puritans and others opposed to the government, who, about that period, established secret printing-offices for the purpose. This decree ordained that there should be only four founders of letters for printing in the kingdom; and that any vacancies which might occur in that number should be filled up by the archbishop of Canterbury or the bishop of London, and six other high commissioners; and it laid the most stringent regulations upon the master-founders respecting the employment of journeymen and the taking of apprentices. These oppressive restrictions were re-enacted for two years, by an Act of Parliament of the 14th year of Charles II., and renewed for limited periods in his 16th and 17th years. They were again revived for seven years in the 1st year of James II., 1685, and finally expired, on the termination of the last-mentioned term, in 1693.

Although Caxton and Wynkyn de Worde had, in the infancy of English printing, established a high character as type-founders, this branch of the art long remained in a depressed state in England, the best types being supplied by continental founders; a circumstance which may, perhaps, be attributed in some degree to the restrictions imposed upon the British founders after their art was separated from that of printing. At the commencement of the 18th century native talent was at so low an ebb, that all the types used by London printers for superior works were imported from Holland. William Caslon, who was originally employed in engraving on gun-barrels, and in cutting ornaments and letters for the use of book-binders, has the honour of removing this stigma upon English ingenuity. Having executed some remarkably neat letters for lettering books, he was induced to attempt punch-cutting; his first engagement in this way being for the Society for Promoting Christian Knowledge, for whom he executed an Arabic fount about the year 1720. Caslon was encouraged and assisted by Bowyer; and he soon attained a reputation which not only put an end to the importation of Dutch types, but occasioned a demand for his own on the Continent. His foundry was continued by his descendants, and is still in operation. Another name memorable in the history of English type-founding is that of John Baskerville, of Birmingham, who died in 1775. His stock of beautiful types was sold to a literary society in Paris, and used for printing a splendid edition of the works of Voltaire; his widow having failed to obtain either a purchaser in England, or sufficient encouragement to induce her to continue his business. The history of the early British founders is minutely given in a very rare pamphlet, published in 1788, by the eccentric Edward Rowe Mores, entitled 'A Dissertation upon English Typographical Founders and Founderies;' and Hansard, in his 'Typographia,' has reprinted most of the information collected by Rowe Mores, together with notices of more recent type-founders. In France the names of Breitkopf and Didot attained high celebrity for improvements in type-founding. The Imperial printing-office at Vienna, where punch-cutting and type-founding are carried on, possesses probably the most numerous collection of foreign alphabets having distinct characters.

The first and most important operation of a type-foundry is the formation of the punches, which are well-tempered pieces of steel, each of which bears on its face a single letter, formed with the greatest possible accuracy by filing, cutting, and punching the hollows with smaller punches. The face of the punch exactly resembles that of the finished type: the letter being reversed, and in high relief. The punch-cutter, in addition to the care and judgment required for making the letter of precisely the right size, form, and thickness, so that it may range well with other letters of the same *fount* or set, must consider the best degree of slope for the sides of the letter, so that, on the one hand, he may avoid making them so vertical that the lines will be weak, and easily broken or battered; and, on the other, that they may not, owing to too rapid an increase of thickness towards the base, produce a thick blurred impression when printed from. When the punch is completed and hardened, it is struck into a piece of copper, which, when it has received the impression from the end of the punch, is called a *matrix*, and forms a mould for the face of the type. The striking of the matrix, like every other operation in the formation of the mould, requires great nicety, because, if the punch be not held perfectly vertical, the face of the type will not be at right angles with its sides, and the impression will consequently be uneven. The depth of the impression is also of consequence, as it affects the height of the type; but this may be regulated by filing the face of the matrix. The sides and end of the matrix are then accurately squared; perfect truth in this respect being necessary, in order that, when the matrix is adjusted in the mould, the letter may be perfectly square with that portion of it which is to form the shank, or *body* of the type, and may also have its proper position with reference to the top and bottom of the body; so that when the types are set up together and printed from, the letters may not only be upright, but may also range in a perfectly straight line. The *mould*, of which a representation is annexed, consists of two halves, each of which is made of steel, and attached, for convenience of holding, to a piece of wood. The two halves of the mould are so formed, with projecting blocks and recesses to receive them, that they may be instantaneously fitted together, as shown in the cut, leaving a square funnel-shaped opening at the top, by which the type-metal is poured in, and below it the actual mould for the body of the type, with the matrix at the bottom to form the letter or face of the type. The two halves of the mould are so constructed that they will slide a little upon each other, laterally, so as to vary the thickness of the body of the letter, that the same mould may be used, with different matrices, for casting every letter of a fount, from i or l, which have very narrow bodies, to m or w, which have wide bodies. The type-metal is usually melted in a small cast-iron pot, set in brickwork with an enclosed fire under it, and is poured into the mould by a very small ladle. The caster then jerks the mould quickly upwards by a peculiar motion of his arm, and thereby expels the air, and forces the fluid metal to enter the cavities of the matrix. When the metal is set, the caster removes the pressure of the long curved spring at the bottom of the mould, and thereby relieves the matrix from the face of the type. The mould is then separated, and the type is removed by the application of one of the hooks attached to the upper part of each half. Complicated as these operations appear in description, the closing of the mould, casting the type, releasing the spring, opening the mould, and removing the type, are all performed in about the eighth part of a minute; so that an expert workman will cast 500 letters in an hour.



When the types leave the caster, each of them has a small block of metal attached to its shank, being that which filled the throat or funnel of the mould. These are removed by a boy, who takes up the types by their edges, or rather by the top and bottom of the body, and breaks off the superfluous metal by a motion almost too quick to be followed by the eye. The average number thus treated in an hour is 2000, but some boys can break off about 5000. The next operation is rubbing the flat sides (but not the edges) of the types upon a piece of gritstone, the fingers of the rubber being protected by pieces of tarred leather: this also is commonly done at the rate of 2000 per hour. The types are then set up by boys in long rows or lines, and these are firmly secured in long frames, which hold them together while the dresser scrapes or polishes the flat surfaces which form the top and bottom of the body, and cuts a groove or channel along their lower ends by means of a small iron plane. While they are in the frame the types are also *bearded*, an operation which consists in planing away to a bevel the upper angle of the body at the feet of the letters. After dressing the types are tied up in such lines as may be convenient, and the proportionate numbers of every type of which a fount consists are selected. All the types belonging to one fount are distinguished by one or more grooves or *nicks* across the lower edge or bottom face of the body, by which simple contrivance the compositor is enabled to see, or even to feel, without looking at the face of the letter, when a type is inverted. These nicks, which should be different in number or position in each fount used in a printing-office, are formed by the insertion of one or more wires in the mould, or they are cut by a plane while they are in the long frames.

Although the composition of type-metal varies greatly in different countries, and even in the practice of different British founders, lead almost invariably forms the principal ingredient. Some of the earliest founders are supposed to have used iron to harden it; but in modern times regulus of antimony is commonly employed for the purpose. Different founders use different alloys, and in different proportions, and this frequently forms a trade secret. The size of the type also occasions a difference, as a small type requires to be harder than a large type.

An invention has also been introduced by which a coating of copper is given to the face of the type by an electro-galvanic process, rendering it much more durable at a moderate expense.

Some letters, from their peculiar form, require more care than others, owing to the projection of certain prominent points beyond the shank or body of the type. Such are called *kerned* letters; and, from their greater liability to injury, rather more than a due proportion of them is cast with a fount. In the common Roman alphabet, f and j are the only kerned letters; but in an italic fount, *d*, *g*, *j*, *l*, and *y* are kerned on one side, and *f* on both sides, and some of the capitals also. As the kerned f cannot be placed close to another f, an i, or an l, it becomes necessary to cast what are called *logotypes*, or types containing two or more letters cast on one body. Those in common use are ff, fl, fi, ffi, and ffl. An attempt was made on a very extensive scale in the last century to introduce the use of types bearing whole words or syllables, under the name of *logography*, or *logographic printing*, but although an edition of Anderson's 'History of Commerce,' in four quarto volumes, 1787–9, and some other works, were printed in this way, the scheme was eventually abandoned.

As the several letters of the alphabet are, in common printing, required in very different proportions, the number cast of each letter in a fount needs to be carefully regulated. The proportions vary in different languages, and in different kinds of work; but for ordinary English book-work they are about as follows:—

a	8500	n	8000	ff	400
b	1600	o	8000	fi	500
c	3000	p	1700	fl	200
d	4400	q	500	ffi	150
e	12,000	r	6200	ffl	100
f	2500	s	8000	æ	100
g	1700	t	9000	œ	60
h	6400	u	3400	,	4500
i	8000	v	1200	;	800
j	400	w	2000	:	600
k	800	x	400	.	2000
l	4000	y	2000	'	700
m	3000	z	200		

To the above are added accented and dotted letters, in numbers ranging from 100 to 250; numerals 1 to 9, and 0, from 1000 to 1300 each; and notes or marks of reference, parentheses, brackets, &c., in number varying from 60 to 300. The number of CAPITALS supplied with such a fount ranges from the lowest number, 80 (Z), to the highest, 800 (I), with 40 of Æ and 30 of Œ. Of SMALL CAPITALS, the number required in ordinary cases is about one-half that of large capitals; and *Italics* are also supplied in small numbers. Spaces, which are pieces of metal resembling the shanks or bodies of letters, and used to separate words, are cast of various thicknesses, to enable the compositor to *justify* his work, or to fill up each line to the same degree of tightness, by varying the spaces between the words. Of the smallest kind, which are called, from their extreme thinness, *hair-spaces*, 3000 are supplied with a fount of the above extent. Of the three next sizes, called *thin*, *middle*, and *thick spaces*, the numbers are 8000, 12,000, and 18,000 respectively. The next in order are n-*quadrats*, or spaces equal in body to the letter n, of which 5000 are required; and m-*quadrats*, double in thickness to the last, and similar in body to the letter m, which is exactly square, or as wide as it is deep, of which the number is 2500. In addition to these are larger quadrats, equal in body to two, three, or four m's, which are used for filling up lines at the end of a paragraph, or in poetry, and for setting up blank lines in order to separate two paragraphs. These are supplied by weight, according to the kind of work for which the fount is required.

Although all British founders employ the same names for types of similar size, it is to be regretted that perfect uniformity in the sizes is not sufficiently attended to to allow the types of different foundries to be used together without inconvenience. The subjoined specimens show the various sizes employed in England for book-work, beginning with the largest, and descending to the most minute :—

1. *Great Primer* is the largest type ever used for printing books. It is seldom employed for anything excepting large folio Bibles, and on this account is sometimes called *Bible Text*. The French call this type *Gros Romain*, and the Germans, from its having been the third of seven sizes formerly used, name it *Tertia*. About 51¼ m's in width, or the same number of lines in depth, occupy a foot.

2. *English*, called by the French and Dutch *St. Augustin* (from which it is supposed to have been first used for printing the works of that author), and by the Germans *Mittel*, as the middle of the seven sizes above alluded to, is used for printing Bibles and other works in folio and quarto. There are about 64 m's to a foot.

3. *Pica*. This type is much used for printing the text of standard library works, and is generally referred to by printers as a standard for the measurement of work. Leads, brass-rules for printing lines, braces, or quotations, &c., are always made to so many Pica m's, whether used with this type or not. In France and Germany it bears the name of *Cicero*, apparently from having been originally used in printing his Epistles. 71 Pica m's go to a foot.

4. *Small Pica*, called *Philosophie* in France, and *Brevier* in Germany, is a type very extensively used; perhaps more than any other. About 83 m's go to a foot.

5. *Long Primer*. This neat type, which is much used for printing works in duodecimo, is called *Petit Romain* in France, and *Corpus* in Germany; the latter name being probably derived from its use in printing the 'Corpus Juris :' 89 m's of Long Primer go to a foot.

6. *Bourgeois* appears, by its name, to have come originally from France; but the French type which comes nearest to it is now called *Gaillarde*. Hansard states, in the article 'Type-founding,' in the 'Encyclopædia Britannica,' that the Germans have no type corresponding with this. It is half the size of Great Primer, and about 102 m's go to a foot.

7. *Brevier*, called in France *Petite Texte*, and in Germany *Petit* or *Jungfer* (maiden letter), derives its English name, most probably, from its having been first used for printing breviaries, or Roman Catholic church-books. It is employed for printing small works, and for notes to those printed in larger type. About 112½ m's go to a foot. It is a type very much used, and is that employed for the text of the 'English Cyclopædia.'

8. *Minion* (French, *Mignonne;* German, *Colonel*) is used principally in newspapers, although some Bibles and prayer-books, and pocket editions of other works, are printed in it. It is half the size of English; and 128 m's go to a foot.

9. *Nonpareil* (French and German *Nonpareille*). Hansard observes of this beautiful type, that at its introduction it was, of course, without a peer in comparative size to the larger types; and he thinks that it still retains its character, and that every smaller type is below the compass that any eye of medium sight is able to read without pain. It is employed in the foot-notes occasionally introduced in this work. Its size is half Pica; and 143 m's go to a foot.

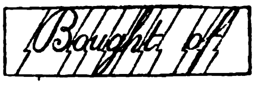
10. *Ruby* is a somewhat irregular size introduced by English founders subsequently to the smaller types given below, and is employed for pocket dictionaries, Bibles, prayer-books, &c. Hansard states that it was originally a Nonpareil with short ascenders and descenders, cast on a smaller body; or sometimes a Pearl, cast on a larger body, to give it an open appearance. The body of Ruby is about half that of Long Primer, and about 163 m's go to a foot.

11. *Pearl*, called by the French *Parisienne*, and by the Germans *Perl*, was the size cut next to Nonpareil. It is a beautiful letter for printing miniature editions, and is sufficiently clear to be read with facility by persons of strong sight. It is also much used for notes to books printed in larger type. Pearl is half the size of Long Primer; and about 178 m's go to a foot.

12. *Diamond*, to which the same name is given in France and Germany, is the smallest type used in this country, and is rarely employed excepting for Notes. Books printed wholly in this letter are typographical curiosities, and require the greatest possible care in printing. The stereotyping of Diamond type was formerly deemed impracticable, but it has of late years been successfully accomplished. The difficulty of making and composing type so exceedingly minute may be conceived from the fact that about 2500 of the letter i go to a pound weight, and about 5000 of the thinnest space. Henri Didot, the eminent French type-founder, cut a type smaller than the English Diamond, its fount being half Nonpareil, while Diamond is half Bourgeois; and Hansard states, in his 'Typographia,' that Mr. Hessemer, who cut the Diamond of the Caslon foundry, commenced a smaller fount to rival that of Didot. From the same authority it appears that the Dutch were the first in Europe to cut Diamond type, and Mr. Fry the first in England.

Of types larger than those employed for book-work, the first, in an ascending series, is called *Paragon ;* the next is *Double Pica*, which is twice the size of Small Pica; above which are *Two-line Pica*, *Two-line English*, *Two-line Great Primer*, and *Two-line Double Pica*, each of which is double the size of the common type from which its name is taken. One other type, *Canon*, has also a distinctive name; but all above it are called, according to the number of Pica m's in their height, *Five-line Pica*, *Six-line Pica*, &c. Large letters, such as are used in posting-bills, were formerly cast in sand-moulds, and hence called *sand-letters ;* but the fourth William Caslon introduced a convenient method of making matrices for such types, without the use of punches, by cutting the letter completely through a piece of copper or brass from one-eighth to one-fourth of an inch thick, making the apertures wider on one side than on the other; and then riveting the plate so cut with the face (or side at which the apertures are smallest) downwards upon a smooth surface of brass, which forms the face of the letter. They are now usually cut on a soft wood, for the special purpose required.

Ornamental types are made in endless variety for printing cards and circulars, and for other fancy purposes; but of these it is only necessary to mention particularly what is called *Script* type, which is cut to imitate writing. The early attempts to imitate cursive characters by letters cast upon a square body were very clumsy, it being impossible under such circumstances to give an easy inclination to the letters, and to make them join neatly. To remedy this M. Firmin Didot invented types with a body the sides of which form oblique angles with the top and bottom, and are so formed that they will, nevertheless, lock firmly together, without any inclination to slide upon each other. This may be readily understood from the annexed cut, which represents the words "Bought of" set up in script type, with a triangular piece of metal added at each end to allow of their being wedged up with type or quadrats of the usual form. Didot cast, on bodies of this form, the component parts of letters; but his idea was improved upon by English founders, who cast the letters complete, and provide for every variety of junction which may be required by casting some of the letters of different bodies, according to the relative positions they may be required to occupy. More recently, some founders have succeeded in casting types on a square body, which answer the same purpose as Script, and these, on account of the greater facility of composition, are more generally used for common work.



Many schemes have been suggested for facilitating the manufacture of types by the use of machinery; but as these have failed to come into general use, they may be dismissed with a very brief notice. One of the earliest formed part of a very comprehensive project for the improvement of printing brought forward by Mr. William Nicholson, editor of 'Nicholson's Journal,' about 1790. Another, which was patented about 1823, by Dr. William Church, of Birmingham, proposed to cast types at the rate of 75,000 per hour, and to melt and recast them after each time of printing from. A third, of less pretensions, as it did not propose to dispense with the subsequent rubbing and dressing, was the process of Henri Didot, patented in England by Louis John Pouchée, for casting at the rate of 24,000 per hour; which has been practised, although it did not supersede the ordinary mode of casting by hand.

More recently an ingenious machine has been invented. In this, by turning a crank-wheel, the metal is injected with considerable force into the type-mould, brought by the machinery in front of a reservoir of metal kept fluid by a gas-fire beneath it, and by a continued movement is delivered out of it, at a rate varying from six to ten times the rapidity with which the operation can be performed by hand. Both in casting by hand, and in the machine, the mould is liable to become obstructed by particles of the metal remaining, when it has to be brushed clean. When this happens to the machine, it ceases to act, and thus at once informs the operator of the defect.

Composing.—The processes in the business of a compositor are distributing and composing.

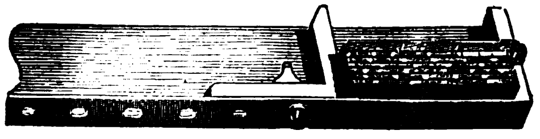
1. *Distributing.*—Each compositor works at a sort of desk called a frame, and in most instances he has the desk or frame to himself. The frame projects laterally from the wall, having the light on the left hand, unless when lighted from the top. The front and lowest part of this frame is about as high as the elbow or ribs of the compositor, in order to allow his arm to move freely over it. The back is about a foot or 15 inches higher. The space between is about 28 inches, and is divided into two inclinations. Upon the lower and flatter of these rests the *lower-case ;* on the upper and more acute inclination rests the *upper-case*. Each frame is constructed to hold two pair of *cases*. Each pair of cases contains all the letters of the alphabet, whether small letters or capitals, as well as points, figures, &c., &c. One of these pairs

of cases is usually occupied by the *Roman* letters, the other by the *Italic*. The upper-case is divided into 98 partitions, all of equal size; and these partitions contain two sets of capital letters, one denominated "full capitals," the other "small"; one set of figures; the accented vowels; and the marks of reference for notes. The lower-case is divided into partitions of four different sizes, some at the top and ends being a little smaller than the divisions of the upper-case, others nearer the centre being equal to two of the small divisions, others equal to four, and one equal to six. In all, there are 53 divisions in the lower-case. The inequality in the size of the cells of the lower-case is to provide for the great differences as to the quantity required of each letter.

The proportion in which a particular letter is required renders it necessary that the cells of the lower-case should be arranged, not as the letters follow each other alphabetically, but that those in most frequent use should be nearest the hand of the compositor. The point at which he stands is not far removed from the centre of the lower-case, and within a range of about six inches on every side lie the c, d, e, i, s, m, n, h, o, p, u, t, a, and r, the letters in most frequent use. The spaces, which he wants for the division of every word, lie close at his hand at the bottom of the central division of the lower-case. It must be quite obvious that the man who contrived this arrangement saved a vast deal of time to the compositor.

As *distributing* is a part of the compositor's business for which nothing is paid direct (the payment for that labour being included in the price of composition), it is necessary, before he can compose, that he should put type into his cases, as no one will have done this for him. This operation is a most beautiful process in the hands of an expert compositor; and probably no act which is partly mental and partly mechanical offers a more remarkable example of the dexterity to be acquired by long practice. The workman, having prepared a quantity of type which has been already printed from, either in a form or page (terms which will be described under *making-up*, &c.), loosens the lines sufficiently to allow them to be washed free from dirt. While the types are yet moist, in which state they adhere sufficiently to prevent them with care from falling asunder, he lifts a portion of the type as it has been arranged in lines upon a slip of brass rule. This he rests upon the middle finger of his left hand, supporting one side with his thumb, towards which he somewhat inclines the whole handful. In each letter there is a nick or nicks, to indicate the bottom edge of the letter. Keeping the face towards him, and the nick uppermost, he takes up one or two words between the fore-finger and thumb of his right hand, and drops the letters, each into its proper place, with almost inconceivable rapidity. His mind has to follow the order of the letters in the words, and to select the box into which each is to be dropped, while his fingers have to separate one letter from another, taking care that only one letter is dropped at a time. This is a complicated act; and yet a good compositor will distribute three or four times as fast as he composes—that is, he will, if necessary, return to their proper places 50,000 letters a day. The letters being inverted in printing, are not read as they are read in a book, and thus "to know his p's from his q's" is a difficulty to a beginner.

Standing before the pair of cases which contain the Roman letter, he holds in his left hand what is called a *composing-stick*. This is a little iron or brass frame, one side of which is moveable, so that it may be adjusted to the required width of the page or column which the workman has to set up. It is made perfectly true and square; for without such accuracy the lines would be of unequal length. It is adapted to contain not more than about seventeen lines of the type of the present work.



Composing-Stick.

The copy from which the compositor works rests upon the least-used part of the upper-case. The practised compositor takes in a line or two at a glance, always provided the author writes an intelligible hand —which virtue is by no means universal. One by one, then, the compositor puts the letters of each word and sentence into his stick, securing each letter with the thumb of his left hand, which is therefore continually travelling on from the beginning to the end of a line; the letters being arranged on a thin slip of polished brass of the same height as the type, called a *setting-rule*, and which is shifted from behind each line to the front when completed, the roughness of the types being thus avoided. His right hand goes mechanically to the box which he requires; but his eye is ready to accompany its movements. In each letter, as we have stated, there is a nick or nicks, to indicate the bottom edge of the letter; and the nick must be placed outwards in his composing-stick. Farther, the letter must also be placed with the face upwards, so that two right positions must be combined in the arrangement of the types. If the compositor were to pick up the letter at random, he would most probably have to turn it in his hand; and as it is important to save every unnecessary movement, his eye directs him to some one of the heap which lies in the right position, both as regards the face being upwards and the nick being outwards. This nick is one of those pretty contrivances for saving labour which experience has introduced into every art, and which are as valuable for diminishing the cost of production as the more elaborate inventions of machinery. When he arrives at the end of his line, the compositor has a task to perform in which the carefulness of the workman is greatly exhibited. The first letter and the last must be at the extremities of the line: there can be no spaces left in some instances, and no crowding in others, as we see in the best manuscript. Each metal type is of a constant thickness, as far as regards that particular letter, though all the letters are not of the same thickness. The adjustments, therefore, to complete the line with a word, or at any rate with a syllable, must be made by varying the thickness of the spaces between each word. A good compositor is distinguished by uniformity of spacing: he will not allow the words to be very close together in some instances, or with a large gap between them in others. His duty is to equalise the spacing as much as he possibly can; and this is, in some cases, very troublesome. When the workman has *filled his stick*, as it is called,—that is, has set up as many lines as his stick will conveniently hold,—he lifts them out into what is termed a *galley*, by grasping them with the fingers of each hand, the setting-rule supporting them in front, and thus taking them up as if they were a solid piece of metal. The facility with which some compositors can lift about what is called a *handful* of moveable type, without deranging a single letter, is very remarkable. This sort of skill can only be attained by practice; and one of the severest mortifications which the printer's apprentice has to endure is, to toil for an hour or two in picking up several thousand letters, and then to see the fabric destroyed by his own clumsiness, leading him to mourn over his heap of broken type—technically called *pye*—as a child mourns over his fallen house of cards.

Letter by letter, and word by word, is the composing-stick filled; and by the same progression the galley is filled by the contents of successive sticks.

In composing pages for a book, when the compositor has set up as many lines as fill a page, he binds them tightly round with cord, and places them under his frame; this is *making-up*. We need scarcely say that the sizes of books greatly vary; but they are all reducible to a standard determined by the number of leaves into which a sheet of paper is folded. The most common size is called *octavo*, the size of Macaulay's 'History of England,' and this contains 16 pages to the sheet; the next is *duodecimo*, the size of the 'British Almanac,' containing 24 pages to a sheet; and the next *octodecimo*, or eighteens, containing 36 pages in a sheet. There are many other sizes, such as the larger *quarto*, which is the size of the present work, and the smaller *twenty-fours*. Much skill and ingenuity are employed in devising what are called schemes of imposition. In regular and perfect sheets of a work this is usually all settled, but in the endings of volumes the chances are much against their forming complete sheets, and the compositor has then to consider how he can best dispose the pages so as to avoid waste of paper and expense in working at press.

In every case, when a sheet is complete, the compositor arranges the pages in proper order upon the imposing-stone, which is a large table with a polished stone or iron top: he places around the whole a stout iron frame, called a *chase*, and surrounds each page with pieces of wood called *furniture*, so as to leave an equal margin to every page, and finally wedges the whole tightly together with a wooden mallet in the chase. If the work is properly executed, the pages thus wedged up. constituting one side of a sheet, termed a *form*, are perfectly tight and compact; and the *form* may be carried about with as much ease as if it were composed of solid plates, instead of being formed of 40,000 or 50,000, or even 100,000 moveable pieces, weighing from a few pounds to a couple of hundred-weight. In this state a *proof* is pulled; that is, a single impression is taken at the press.

In newspapers, periodical works, and many other works in which much alteration is anticipated in subsequent stages from the author, the type or *matter*, as it is technically called, is wedged in brass galleys, in what are called *slips*, and after it has undergone the process of correcting, it is then made up into pages and imposed, or arranged in order to be worked on the paper.

The inventive faculty has also been applied to methods for facilitating the arrangement of the type, as well as for type founding. In the Report on Printing, &c., of the Paris Exhibition of 1855, Mr. Knight says:—"During the last twenty years there have been various attempts to produce a machine that will, to some extent, supersede that portion of manual labour in printing which is called 'composition.' Without attempting to describe the various contrivances by which a more rapid method of arranging moveable types was to be effected than by the ordinary method, it may be sufficient to say that by keys, like those of a pianoforte, some force might be applied to remove a single letter from its proper receptacle, and arrange it in a combination of words and sentences. . . . . There were several composing and distributing machines in the French Exhibition, but the most remarkable one, and that which appears to me, as it appeared to M. Didot and other competent judges, to approach nearer than any other invention to the accomplishing of this long sought for object, is thus entitled—'Machine à composer et mettre bas pour l'usage de l'imprimerie, composée et executée par Christian Sörensen.' It was stated that a Copenhagen newspaper, of which a copy was shown, had been printed for some time by this method. It would be impossible to convey an adequate notion of the details of this machine without drawings. I will endeavour briefly to state the principle :—The types are of the usual thickness and height. In the centre of each type, in the front, is a deep nick of a dovetail shape, which fits upon a metal edge, so that the type cannot be displaced. But of 111 letters which are required in the fount, each letter has two, three, or four nicks cut at right angles, the nicks of no one letter being the same as another. A cylinder, which may be described as a large basin, has a number of metal edges placed vertically in its sides, upon which the types without any regard to order, being the matter for distribution, are rapidly slid by the dovetail nick.

"When the basin is filled, it is inverted upon a cylinder of corresponding size below. Upon the rim of this cylinder is a separate opening for the reception of each of the 111 letters, but no one opening is like another. The distributing and the composing go on at the same time. The compositor is seated; with a treddle he moves the upper cylinder, which, as it slowly revolves, finds in the lower cylinder, which is stationary, a fit place for every separate letter as it descends by its own gravity to the bottom of each metal edge. The *n* having two broad nicks, one about $\frac{1}{8}$ of an inch from its top, the other at the same distance from its bottom, falls into the *n* opening, which, having points corresponding, alone can admit it from its similarity of form, while the *u* having four nicks, two broad and two narrow, passes into its own division, and cannot be confused with the *n*.

"But whilst this process of distribution is steadily proceeding, without any care but to keep the upper cylinder occasionally supplied with new material for its operation, the process of composition is rapidly going on. The compositor sits before a compact little frame of keys, each key having a connecting wire for each division of the lower cylinder. He strikes a key and the lower letter is instantly detached and falls into a funnel-shaped receptacle below, where, without being inverted in any way, it runs into a groove, and arranges itself in its proper order, in the line of its fellows. This is a long line of several feet. By an ingenious contrivance each such line is passed on one side, as it is completed, to another workman, who takes up as many letters as will fill the due width of his page or column, and spaces out the words in the ordinary way. I saw 1000 letters thus placed in line in the short space of four minutes, and the spelling and punctuation appeared as correct as in most matter of common composition before it is read. When the necessary loss of time in refilling the cylinders, and through other hindrances, is taken into account, it was stated by the exhibitor that 50,000 types are set up and distributed each day. This gives a rate of about 6000 an hour, which is treble that of the ordinary compositor's rate."

Other machines, designed to attain greater rapidity, or of more simple and cheaper construction, have been produced since that exhibition; and a few have been brought into actual work in printing-offices, but without sufficient success to insure their general adoption. Among the latest of these inventions is that of Mr. Young, in which the keyed arrangement is adopted, the receptacle being filled as described above. The action of the lever knocks aside the letter required, which instantly drops into a special groove running down an inclined plane, and this leads to the general issue, where it is propelled by the action of a lathe, at the end of which it arranges itself in its desired order in an upright position, and is thus passed to a frame of divided spaces to admit the arranged types in long lines. As one space fills, a lever lifts it a line, until the whole is filled, when its place is supplied by an empty one. The frame thus filled is removed to the justifying machine. Here the frame is placed so as to bring the uppermost line on a level with an instrument brought by a screw to the width of the line required. The justifier glances his eye along the line, corrects any error that he detects, and slides as much as the line of the justifying machine will take with regard to the end or division of a word, and then spaces it tight. The instrument then drops a line, and the process is repeated till a page is formed, which is then removed. It is stated that one player will compose 13,000 letters per hour, and that this will occupy three compositors in justifying. Working nine hours a day, this would be 117,000 letters for four compositors, or about 29,000 for each; while at the common case they could not produce more than 18,000 at most by the usual process, which however includes the distribution, which must with this machine be effected by a compositor, although the inventor has in hand (Nov. 1860) a machine for performing the distribution also. When distributed, each type has to be set up separately, in order to be placed in their receptacles, and this is done by boys, at about the same rate as is done in *Type-founding*.

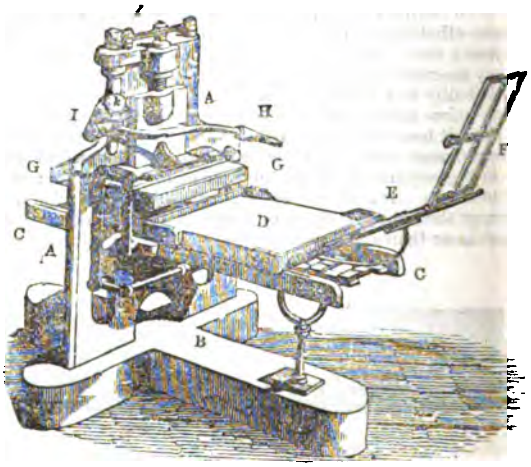
There is one drawback to all such machines, that appears almost impossible to overcome, and will greatly prevent their general use. They may arrange types with a rapidity far greater than is attainable by man's fingers in lifting them; but the superiority of machinery consists mainly in its being continuous. If this fails, the advantage is lost, and the interruptions are costly. Now in composing no one can move his fingers, either on the keys of a machine or into the boxes of a case, faster than he can read the copy. Few know better than a compositor the difficulty there is in reading most manuscripts. Even the change of a hand-writing is often an obstacle, and of many authors the writing is so peculiar or so bad as to take considerable time to decipher; and many others neglect the punctuation, which a good compositor ought carefully to attend to. On newspapers the copy is often from a copying-press, and is faint or obscure, or is written on thin paper with a pencil, with like defects. Nor is there any provision for the use of a word in italic, or in any different alphabet, such as Greek or Hebrew. Thus, in manuscript works, the worker at a composing machine would necessarily lose so much time in reading his copy as greatly to reduce his rate of speed; for if he mistake, the fault has to be corrected. This cannot be done by machine, and the correction frequently takes as much time as the original composition. With mere reprints they may answer better; but even with them we believe the idea of employing the cheap labour of boys has been given up, and it is found more remunerative to engage men already acquainted with their business as compositors.

Printing-press.—The term printing-press is applied to the machine used for letter-press printing, lithographic printing, or copper-plate printing, but more usually the first named, the others being called rolling-presses. The date of the invention of the printing-press is unknown, but some contrivance for this purpose must have been used as soon as printing by blocks or types was introduced. The increased force requisite to make an impression, the size of the surface to be printed from being increased, would soon suggest recourse to some of the simple machines or mechanical powers for the modification of the power requisite to obtain the necessary pressure. The screw, as applied in the common screw-press, would obviously suggest itself; and accordingly, in all the earlier printing-presses, the screw alone is used.

The operations to be performed in the process of printing will point out the essential parts of a printing-press. The types, being set up and arranged in a form of suitable dimensions, have to be inked; this is effected by passing across them a cylinder, or roller, covered with an elastic composition of molasses, glue, and tar. The paper to be printed has to be laid on the types when inked, and then the requisite pressure for making the impression has to be applied.

The earliest form of printing-press very closely resembled the common screw-press, as the cheese or napkin press, with some contrivance for running the form of types, when inked, under the pressure, and back again when the impression was made. This rude and inconvenient form of press was superseded by the invention of Blew, a printer of Amsterdam. Other improvements were from time to time introduced; but they were all superseded, about the commencement of the present century, by an invention of Lord Stanhope.

In the accompanying diagram of the Stanhope press, A is a massive frame of iron, cast in one piece, forming the body of the press, and



firmly fixed to the cross B, or wooden foundation. The table C carries the form of types D, which, being placed on a carriage, traverses the table backwards and forwards, motion being given to it by means of the crank-handle acting underneath the table. To the carriage are attached the tympans E, which are light frames covered with parchment, and so constructed that the inner tympan just lies within the outer tympan. Some blanketing is placed between the tympans, so as to equalise the pressure upon the surface of the types. To the outer tympan is attached the frisket F. The sheet of paper to be printed being placed on the tympans, the frisket is turned down upon it; and then the frisket and tympans are turned down upon the form of types. The frisket is covered with paper or parchment, cut out so that the sheet to be printed, when placed between the tympans and frisket, and folded down together on the form of types, may be in contact with the surface of the types; while the remainder of the frisket-sheet preserves the margin from being soiled.

The form of types being inked, and the tympans and frisket, with the sheet of paper between them, folded down on the form, the whole is run, by turning the crank-handle, under the platen G, which is a massive plate of cast-iron, moveable up and down perpendicularly, its weight being rather more than counterbalanced by the weight I at the back. The pressman pulls the handle of the bar H towards him, or across the press, and thus communicates motion to *k* and *l*, and causes the spindle *m*, which sustains the platen, to descend and produce the requisite pressure. The principal improvement of the Stanhope press consists in the manner in which the descending motion is given to the screw. This depends on the properties of the bent lever, and may be explained in the following manner:—It is a neces ary consequence of the peculiar combination and arrangement of the bent lever here employed, that on the handle H being moved, the platen descends rapidly at first; but as the platen comes very near to the extreme point of its descent. the motion is extremely slow. But at this instant the platen is pressing the paper upon the types, and the pressure exerted being inversely as the rate of the descent of the platen, whose motion at this instant is exceedingly slow, the pressure produced is enormously large. It will be found also that at the instant the platen is at its lowest point, the connecting bar *l*, by which the power applied is transmitted to the platen, passes across the centres of motion of the system of forces; at this instant, as theory points out, the ratio of the pressure produced to the power applied is indefinitely large. The pull having been made, or the pressure produced, the handle H returns to its original position, being taken back by the weight I at the back, which rather more than counterbalances the platen. The carriage is then run back, the frisket and tympans unfolded, and the printed sheet being taken out, the same operation is repeated. The usual rate of printing by the Stanhope press is two hundred and fifty per hour, two men being employed, one to ink the types, and the other as pressman.

The principle of the Stanhope press has been followed out by several subsequent inventors, and improvements of mechanical detail introduced, tending to the economy of time and labour, and to precision of workmanship. In the Ruthven press, the form of types remains stationary, and the plattin is removed to permit the types to be inked; and in this, as well as the Columbian, the pressure is produced by a combination of levers alone, without the use of any portion of a screw or inclined plane.

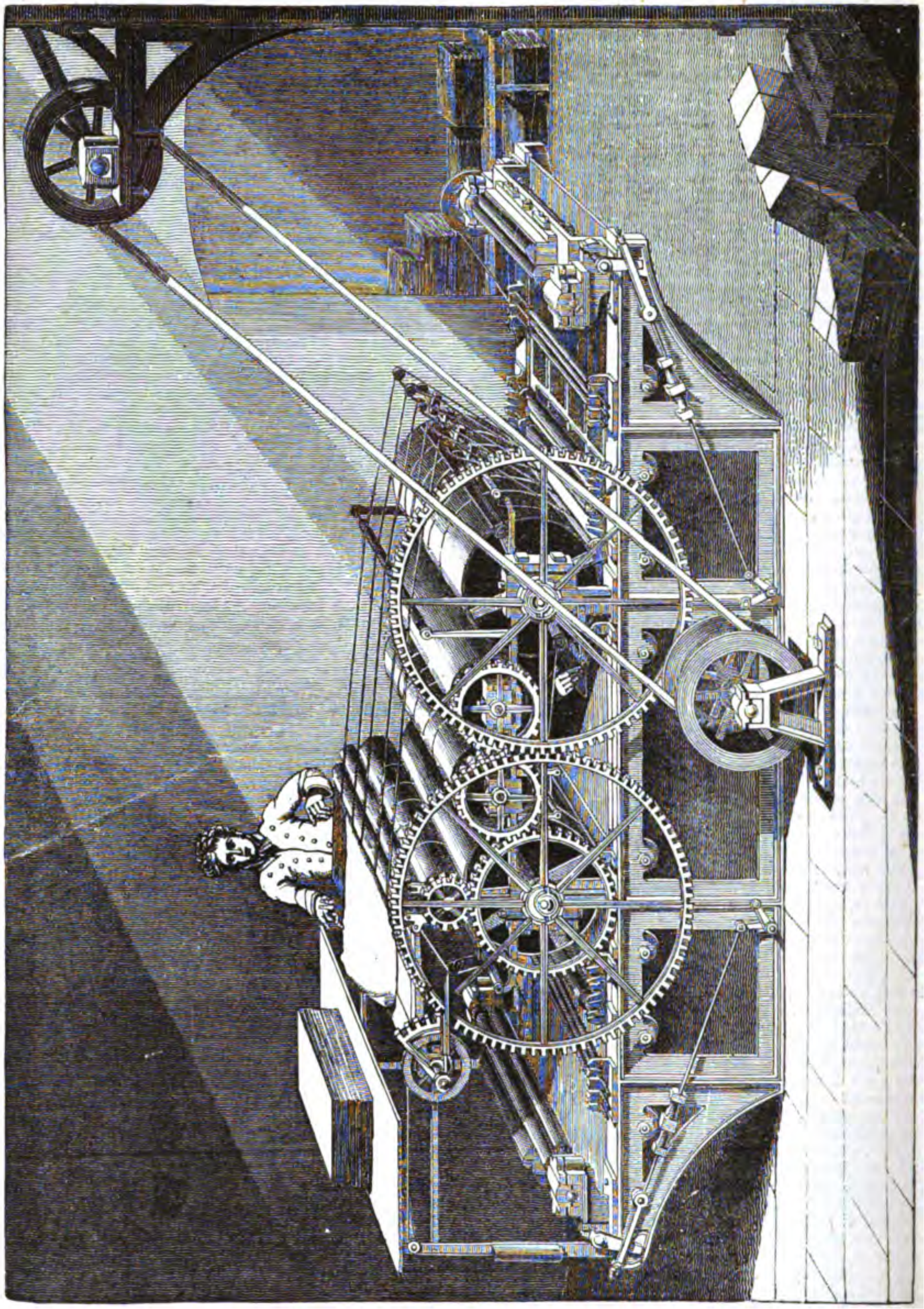
The press for copper-plate printing consists of two cylinders, or rollers, of wood, supported in a strong wooden frame, and moveable about their axes, one placed just above and another just below the level of the table upon which the plate to be printed is laid. The upper roller is turned round by the arms of a cross fixed to its axis. The copper-plate being inked, the paper on which the impression is to be taken, and two or three folds of soft material, as blanketing, are placed upon it. The plate so prepared is moved along the table to the juncture of the two rollers, and the upper roller being turned by the arms of the cross, the plate, with its furniture, is passed through the press. The rollers may be placed nearer to or farther from each other, according to the amount of pressure requisite for making a good impression, that is, according to the depth of the engraving and the degree of blackness which the impression is required to have. With slight modification the same form is used for lithographic printing, to which steam-power has been recently applied very effectively.

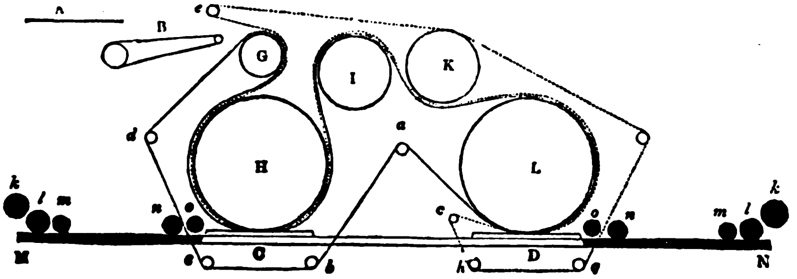
Printing-Machine.—The printing-press, though much improved during the last half-century by the ingenuity of Lord Stanhope and others, is quite inadequate to a rate of production equal to the present demand. The attention of practical men was consequently directed to some more rapid means of production, and as early as 1790, even before the Stanhope-press was generally known, Mr. W. Nicholson had letters-patent for a machine similar in many respects to those which have now come into use. Subsequently Mr. König, a German, conceived nearly the same idea, and meeting with the encouragement in this country which he failed to obtain on the Continent, constructed a printing-machine, and on the 28th of November, 1814, the readers of the 'Times' were informed that they were then for the first time reading a newspaper printed by machinery driven by steam-power. This printing-machine, though highly ingenious, was very complicated, and the machine of König was soon superseded by that of Messrs. Applegath and Cowper, the novel features of which were accuracy in the register, the method of inking the types, and great simplicity in hitherto very complicated parts. Printing-machines may be distinguished into single and double; the single being that in which only one side of the sheet of paper is printed, the double that in which both sides are printed before the sheet leaves the machine. The former is used for newspapers and that kind of printing in which it is not necessary for the two sides of the sheet to "register," that is, for the printing on one side to be exactly at the back of the other; the latter for books, in which it is essential that the printing on one page should correspond with the printing on the other when the sheets are folded. This important object of the register is effected by causing the parts to move at precisely the same speed. This being the principle of the register, its success will depend on great accuracy of workmanship in the mechanical parts. The accompanying representation of the printing-machine will furnish a correct notion of the several parts, and of the way in which motion is communicated to them. A sheet of paper is taken from the pile to be printed (as represented at the left-hand side of the drawing), and put into the machine by one attendant, and taken out printed on both sides by the other attendant, whose hand is shown under the cylinders. The accompanying sketch will show the principle of the printing-machine.

The sheet of paper taken from the table A is laid on the feeder B, which consists of girths of linen, tightly stretched by being passed round two cylinders. By the motion of this feeder the sheet is placed between the two systems of tapes which lie on the cylinder G: these tapes, of which one set is represented by the dotted line, and the other by the thin line, lie two and two over each other on the cylinders and small rollers *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*. The sheet of paper grasped between them is kept clean at the places in which it is in contact with them, and by the motion of the various parts is conducted under the first printing-cylinder H, and receives an impression from the types at C; thence by means of the cylinders I, K, to the second printing-cylinder L, where it receives an impression on the other side from the types at D. Thus printed on both sides, it is taken out at *e* by the attendant. The cylinders I and K are simply for the purpose of conveying the sheet steadily and smoothly from one printing-cylinder to the other. The sheet will be seen to be reversed in its progress from one set of types to the other, descending the left side of the first and the right side of the second printing-cylinder.

An inking-apparatus is placed at each end of the table M, N, which carries the types C, D, and which traverses backwards and forwards under the printing-cylinders L, H, and inking-rollers. The ink, received from a reservoir *k* by the two rollers *l* and *m*, is transferred from them to the surface of the table; the surface of the table inks the rollers *n*, *o*, and these, in their turn, ink the types as they pass backwards and forwards for each impression. The excellence of the printing depends in a great measure on the types being properly inked. In a machine arranged according to the accompanying diagram, the types are touched four times by the inking-rollers for each impression, and by increasing the number of rollers, any perfection of inking may be obtained. The machines commonly used for printing books will print from seven hundred to one thousand per hour, in perfect register; and for newspapers printed on one side only, from four thousand to six thousand per hour.

Steam-power has also been applied to flat machines, which are a modification of the Stanhope press, in which the table, with a form of type at each end, moves backwards and forwards under the platen, which gives the impression to one form while the other is being inked by the rollers. This description of press was for a time supposed to be best adapted for the finer sorts of book-work; but the process was very much slower, and the belief in their superiority of work was not universally admitted. Cylindrical machines were frequently used, not only for newspapers, where rapidity of production was required, but for books containing engravings on wood, where excellence of workmanship was demanded. Several of these machines were exhibited at the Paris Universal Exhibition in 1855, the French printers having devoted much attention to the improvement of cylindrical machines. In his report as juryman on 'Class XXVI.—Drawing and Modelling, Letter-press and Copper-plate Printing, and Photography,' Mr. Charles Knight says, "In the Paris Exhibition, several machines, offering the advantage of more perfect inking, and of preventing what is called 'setting-off' [that is, the sheet becoming blurred by the moist ink being pressed upon], showed that the attention of the French printers had been more directed than with us to the practicability of producing the finest work by the machine instead of by the hand-press. Some of our artists, who have watched the dependence of the wood-engraver on the printer, have long been of opinion that the equal operation of the cylinder is superior to the irregular force of the hand-press. But the heads of our printing establishments have generally considered that the cylindrical machine was only calculated to save labour, and not to produce fine work. Our machine-makers have, therefore, made various labour-saving machines upon the principle of flat pressure, which, as it is the principle of the hand-press, at which the most expensive work was produced, was thought to be the only principle for a more perfect machine. The French, on the contrary, have turned their attention to the perfection of the cylindrical machine, knowing that it had natural advantages which could not be obtained by flat pressure. When a sheet of paper is brought into contact with an inked surface of types, by being laid flat upon that surface, a large body of air has to be expelled by the heavy platen, operating at once upon the whole surface. The cylinder, on the contrary, touches the type, and produces the impression on the paper, line by line, and there is no atmospheric resistance to be overcome. The French printers have, therefore, sought for the improvement of the cylindrical machine. The single-cylinder machine of M. Dutartre produces work which cannot be excelled by the most careful operations of the press. It prints only on one side [the process having to be repeated to 'perfect' the sheet]; and the form passes under a double set of inking-rollers, at each end of the table, before it receives the impression. In the double-cylinder machine of the same inventor, a waste sheet of paper is interposed so as to prevent setting-off; and thus both sides of the paper may be printed at once, without leaving that blurred impression of one side which so commonly disfigures machine-printing. The French printers now do their finest work by the cylindrical machine, and much of their common work by the hand-press." The report goes on to say that, on

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the whole, the average work of the French printers is superior to that of the English. It attributes this partly to the better quality of their paper, which is farther improved by being passed through powerful rollers, thus creating a more even surface, partly by using dry paper instead of wet, partly by the use of silk instead of parchment for tympans in their hand-presses and flat-pressure machines; and other little niceties, the results of long practice based upon scientific investigation. M. Dutartre's double-cylinder machine has been introduced into England; and a patent has been taken out for an improvement in the manufacture of paper, by which the necessity of wetting it to enable it to receive the ink will be removed: we believe, as far as this experiment has been carried out, that it has been successful.

M. Dutartre also exhibited a machine for printing in two colours, for which he received the silver medal. Others were exhibited for printing newspapers; but their rapidity was not equal to ours, as it appears from the report, 6000 sheets perfect being the highest number stated; but several ingenious adaptations and movements are noticed in Mr. Fairbairn's report.

In England, however, the demands of the newspaper press had not been met by even such improved machines as above described. The 'Times' could not be produced sufficiently early at the rate of 5000 or 6000 an hour. Mr. Applegath again employed his inventive faculty, and produced a printing-machine on the vertical cylindrical system, which could produce on one side from 10,000 to 13,000 copies an hour. With such machines the 'Times' has been worked since 1848; and the machine has been used for the production of the 'London Illustrated News,' and other newspapers having a large circulation.

In this machine a central drum 200 inches in circumference, or 64 inches in diameter, turns on a vertical axis. We copy the following description from C. Tomlinson's 'Cyclopædia of Useful Arts and Manufactures':—"The inking-table and the columns of type are secured to the surface of this drum; the columns of type are placed vertically, not conforming to the curve of the drum. This is contrived in the following manner. A slab of iron is curved on its under side, so as to fit the large cylinder, while its upper surface is fitted into facets, or flat parts, corresponding in width and number to the width and number of the columns of the newspaper. Between each column there is a strip of steel, with a thin edge, to print the 'rule,' the body of this strip being wedge-shaped, so as to fill up the angular space left between the columns of the type, and to press the type together sideways, or in the direction of the lines; the type is pressed together in the other direction by means of screws, and is firmly held together. The surface of the type thus forms a portion of a polygon, as already noticed; and the regularity of the impression is obtained by pasting slips of paper on the paper cylinder. The large central drum is surrounded by eight cylinders, each about 13 inches in diameter, also with vertical axes. They are covered with cloth, and upon them the paper to be printed is carried by means of tapes. Each of these cylinders is so connected with the central drum, by means of toothed wheels, that the surface of each must move with the same velocity as the surface of the drum. It will thus be evident that if the type on the drum be inked, and each of the cylinders be properly supplied with a sheet of paper, a single revolution of the drum will cause the eight cylinders to revolve also, and produce an impression on one side of each of the sheets of paper. But for this purpose it is necessary that the type be inked eight times during one revolution of the drum. This is accomplished by means of eight sets of inking-rollers—one for each paper-cylinder. The ink is held in a vertical reservoir (supplied from above), formed of a ductor-roller, against which rests the two straight edges connected at the back, so as to prevent the ink running out. It is conveyed from the ductor-roller by one of the inking-rollers in the following manner:—As the inking-table on the revolving drum passes the ductor-roller, it receives from it a coating of ink, and then coming immediately in contact with the inking-rollers, it inks them; the types next follow and receive from the inking-rollers their coating of ink; and the drum, still revolving, brings the inked type into contact with the paper-cylinders, and the sheet is printed. It must not be forgotten, as one of the distinguishing features of this machine, that the various processes which have just been enumerated for one set of inking-rollers and one paper-cylinder are repeated eight times for every single revolution of the central drum, so that in this period eight sheets are printed and turned out of the machine. For this purpose it is necessary to supply the eight cylinders each with a sheet of paper. Over each cylinder is a sloping desk, upon which a number of sheets of white paper are placed. The layer-on stands by the side of this desk, and pushes forward the paper a sheet at a time toward the tape-fingers of the machine. These tapes seize it and draw it down in a vertical direction, between tapes, in the eight vertical frames, until its vertical edges correspond with the position of the form of type on the drum. When in this position its vertical motion is arrested for a moment; it then moves horizontally, and is carried towards the printing cylinder by the tapes. Passing round this cylinder, it is instantly printed. It is then conveyed horizontally, by means of tapes, to the other side of the frame, and is moved along to another desk, where the taker-off pulls it down. As soon as the sheet is thus disposed of, accommodation is made for another; and as each layer-on delivers to the machine two sheets every five seconds, sixteen sheets are thus printed in that brief space; and this is continued for any length of time, supposing no accident occurs, such as a sheet going wrong, in which case it is the duty of the taker-off to pull a bell-handle, and the machine is instantly stopped by the engine-man. As the type-form on the central drum moves at the rate of 70 inches per second, and the paper to be printed moves at the same rate, if by any error in the delivery and motion of a sheet of paper it arrive at the printing cylinder 1-70th of a second too soon or too late, the relative position of the columns on one side as compared with those on the other side of the paper will be out of register by 1-70th of 70 inches,—namely, one inch,—in which case the edge of the printed matter on one side will be an inch nearer to the edge of the paper than on the other side. . . . . . . All the layer-on has to do is to draw forward the sheets so as always to have the edge of one ready for the machine to take in. If the steam-engine which works the machine be put on a greater speed, the central drum, and all the attendant apparatus, would work with greater rapidity; and such a speed might easily be obtained as to render it impossible for the layers-on to present the paper fast enough to satisfy the improved appetite of the machine; but in any case the machine would not take in the sheets *as* the layers-on choose to present them, but only at those periods, rapidly recurring though they be, which are provided by the peculiar functions of the machine."

Another machine, likewise on the vertical principle, has been invented by the Messrs. Hoe, of America, and several of these have been brought into use in London.

Stereotyping.—The art of stereotype printing is the printing from cast plates of type-metal in lieu of moveable letters or types, and derives its name from the Greek *στερεός*, firm or fixed, and *τύπος*, a figure or type. This art is a remarkable illustration of the tendency of some inventions to return, after a long course of improvement, very near to their original simplicity. In the commencement of the art of printing, solid blocks of wood were used, containing, in one piece, all the words of which a page was composed. A great improvement upon this plan was the use of single letters or types, which might be combined into words and pages, and, after being printed from, might be distributed and re-arranged for another work. Then followed the process of type-founding, or casting the letters individually in moulds, by which they might be multiplied with facility, and being engraved originally upon steel punches, might be executed with greater neatness. Whether the early printers employed logotypes, that is, types for printing whole syllables or words, to any material extent, is not very certain; but it is well known that many persons have proposed, since the introduction of moveable types, the use of such logotypes for the purpose of facilitating the operation of printing; while others have adopted processes which approach more nearly to the old plan of printing from page-blocks, either by fusing the types composing a page into a solid mass, or, as in the modern art of stereotyping, by taking a mould from the page or *form* of moveable types, and using it as the matrix in which to make a solid cast or plate of metal. The face of such a cast is a fac-simile of the types from which the mould is taken, and may be printed from in the same manner as the original form or page.

Many of the accounts of the various projects which bear an affinity to the art of stereotyping, as practised by modern printers, are very indistinct; and the claims of some of the projectors are exceedingly perplexing. Those readers who desire minute information may consult works which enter at length into the history of printing, and especially a very interesting 'Essay on the Origin and Progress of Stereotype Printing,' published in 1820, by Mr. Hodgson, of Newcastle. The subject is also treated at considerable length in Hansard's 'Typographia;' but much of the history contained in that work is derived from the volume before mentioned.

One of the earliest schemes which claims notice in this brief sketch is that which was tried at the beginning of the last century by a Dutchman named Van der Mey. The booksellers Luchtmans, of Leyden, in a letter dated 1801, which was printed by M. Camus, in his 'Histoire et Procédés du Polytypage et de la Stéréotypie,' described some plates or blocks formed by Van der Mey, which had been used in their establishment ever since 1711. These were the forms for a quarto Bible; but a few other works were executed in the same way. They were not cast solid, but consisted of ordinary types, which, after being set up in the usual way, were converted into a solid mass by soldering them together at the back. The great expense of forms prepared in this way, as well as their inconvenient weight and bulk, is quite sufficient to account for the plan having fallen into disuse. It was indeed only applicable in those very rare cases in which it was desirable, in order to meet a constant demand, to keep the forms of type standing; and was preferable to that practice only inasmuch as it avoided the risk of some of the letters being accidentally loosened and misplaced.

William Ged, a goldsmith of Edinburgh, if not absolutely the first, was one of the first to practise stereotyping, according to the common acceptation of the word. His claim to this honour is recorded in a rare pamphlet published by Nichols in 1781, and reprinted in 1819 by Hodgson of Newcastle, entitled 'Biographical Memoirs of William Ged, including a particular account of his progress in the art of Block-printing.' From this work it appears that Ged invented a process for casting whole pages about the year 1725, and that a few years afterwards he and others who were associated with him attempted to apply his invention to the production of bibles and prayer-books for the university of Cambridge. One of the difficulties to be encountered in the introduction of this innovation was the prejudice and opposition of the compositors, who, by the artful production of errors in the forms of type, rendered the casts so incorrect as to bring them into discredit. The scheme was abandoned by the University, and most of the plates were destroyed. A battered and otherwise imperfect specimen, which escaped the melting-pot, is printed in Hansard's 'Typographia.' Ged cast plates for a few other works, one of which was an edition of Sallust, in 18mo, which, according to his son and daughter, was executed in 1736, though Hodgson says that he never saw a copy dated earlier than 1739, and that the edition commonly bears the date 1744. In Hodgson's Essay a page of this work is reprinted, which is a far better specimen of stereotyping than that given by Hansard. This plate, which had been previously printed in the tenth volume of the 'Philosophical Magazine,' is about a quarter of an inch thick.

About the year 1780, Mr. Tilloch, editor of the 'Philosophical Magazine,' conceived the possibility of founding whole pages; he being at that time unacquainted with the prior experiments of Ged. He communicated his idea to Foulis, printer to the university of Glasgow; and they jointly produced several works; some of which were circulated without any intimation of the process by which they were printed. Hodgson gives very good specimens of their work. Finding some inconvenience in the use of blocks of wood for mounting the plates, in order to raise them to the same height as type, these experimentalists tried blocks of brass, having slits through which small screws might pass to secure the stereotype plates; the screws being fastened by nuts on the under side of the brass mounts. In order to bed the plates as evenly as possible, whether the mount were of brass or wood, they interposed a layer of cement between the plate and the mount. In the latter case the thickness and level were adjusted by planing the back or under side of the wood; and in the former by warming the mount, and then placing it, with the plate, into a press, and squeezing out the superfluous cement. An account of the experiments of Tilloch and Foulis was published in the tenth volume of the 'Philosophical Magazine.' Satisfactory as they were, they did not immediately lead to the adoption of stereotype printing.

Towards the latter end of the 18th century, many projects were brought forward in France for multiplying engraved blocks or forms of type by processes more or less resembling that of stereotyping, under the names of polytype, stereotype, &c. In some of these, the form was imitated by striking upon a mass of soft metal in a state intermediate between perfect fusion and perfect solidity, on the principle of the process now practised in France under the name of *clichage*. The extensive issues of assignats by the revolutionary government gave an impulse to such schemes, of which many were devised, and some were brought into operation, in order to render the assignats more difficult of imitation. In 1798 a stereotype edition of Virgil was published by the Didots and M. Herman; and it appears from Hodgson that, before the close of the century, the wood-engravers of Paris sold metal casts of their wood-cuts.

Some of the early experiments of Senefelder, the inventor of lithography [SENEFELDER, in BIOG. DIV.], were directed to the discovery of a means of stereotyping by which he might be enabled to print his own works with a very small stock of type. He formed a composition of clay, fine sand, flour, and pulverised charcoal, mixed with a little water, and kneaded as stiff as possible; and with this paste he made a mould from a page of types, which became, in a quarter of an hour, so hard that he could take a very perfect cast from it in melted sealing-wax, by means of a hand-press. He states that, by mixing a little pulverised plaster of Paris with the sealing-wax, the stereotype plates thus produced were much harder than the common type-metal of lead and antimony. The want of pecuniary means for carrying on this project led him to abandon it, and to contrive a plan for printing from stone. Another ingenious proposal which may be here mentioned, is that of Professor Wilson, of Glasgow, who, in 1797, devised a method of multiplying engraved blocks or plates by stereotype, or rather polytype, impressions, in glass or enamel, which, it was anticipated, would prove very durable, and might be applied with advantage to the prevention of forgery. Hodgson gives specimens of two casts of small wood-cuts produced in this manner.

The revival and introduction into common use of the stereotyping process is, in a great measure, due to the exertions of Earl Stanhope, about the commencement of the present century. Mr. Tilloch communicated to him the result of his experiments, and Foulis, who, as before stated, had been associated with Tilloch, assisted in the trials made at his lordship's seat at Chevening, in Kent. Andrew Wilson also was connected with these operations, and exerted himself much to introduce the process. The latter individual, who received a gold medal from the Society of Arts in 1810, for his "great skill and exertions in stereotype printing," produced several important stereotyped works, of which Hodgson considers his edition of Walker's 'Pronouncing Dictionary,' executed in 1809, to be the best. A specimen of his work, which was printed in the 28th volume of the 'Transactions' of the Society of Arts (pp. 323–4), shows that he was then able to produce very good casting from type as small as Nonpareil and Pearl. In 1803 or 1804 the process which had been perfected at Chevening was communicated to the university of Cambridge, and shortly afterwards to that of Oxford; but the first work printed in this way at the former place did not appear until 1807, and 1809 is the date of the earliest stereotyped book issued at Oxford.

In setting-up a form intended for stereotyping from, the *spaces*, or short pieces of metal by which the words are separated from each other, and the *quadrats*, or larger spaces by which blank lines are filled up, are cast higher than usual. The types are set up and formed into pages in the usual manner, with the illustrative wood-cuts, if there be any; but, instead of these pages being arranged into a form of sufficient size to print a whole sheet, each page, if large, or every two or four pages, if small, is separately locked up in a small frame or *chase*; the pages being surrounded by fillets of wood or metal, which serve in the cast to form a border for attaching the plate to its mount. The face of the types is then moistened with oil, to prevent the mould from adhering to them. A brass frame, rather larger than the page, is laid upon the chase, in order to retain the plaster while in a fluid state, and to regulate the thickness of the mould. The plaster is then poured on the types, and it soon sets into a solid mass, which must be removed from the types with great care, and trimmed on the edges with a knife. The plaster moulds are, in the next place, baked in an oven heated to about 400° Fahr., until thoroughly dry and hard. They are placed upright in a rack, and are usually dried in about two hours. Great care is required in this process, especially when the moulds are large, to prevent them from warping.

After being baked, the mould is placed, with its face downwards, upon a smooth plate of iron, called a *floating-plate*, which lies at the bottom of a cast-iron box rather larger than the mould. The box is then covered in by a lid, the under surface of which is made perfectly flat, and which has the corners cut off, to allow the melted metal to enter the box. The cover is firmly held down by a screw, which is attached to an apparatus by which the box is suspended from a crane. It should be observed that the casting-box and plate are heated to the same temperature as the mould, before it is inserted. The box is then swung by the crane over the metal-pit, which is an open iron vessel containing a large quantity of melted metal, resembling in its composition that used for casting types; and it is lowered into the metal in a nearly horizontal position, being a very little inclined, to facilitate the escape of air from the mould and box. The melted metal runs in at the corners of the box; and, by its greater specific gravity, floats up the plate with the mould, forcing the latter tightly against the lid of the box. By this contrivance the metal is forced, by hydrostatic pressure, into every part of the mould, in the margin of which notches are cut to allow free passage for the metal between it and the floating-plate. After remaining immersed in the metal for about ten minutes, the box is gently raised, and removed by the crane to a trough in which its lower part is rapidly cooled by contact with cold water. While the box is cooling, the caster pours in a little metal at the corners, to fill the space left by the contraction of the metal, and so to keep up the necessary pressure upon the cast. When cold, the contents of the box are removed in a mass, from which the superfluous metal is broken off by blows from a mallet. The plaster mould is then broken away from the cast, the face of which is a facsimile of the types and engravings from which the mould was taken. As the mould is destroyed by this process, it is necessary, when several stereotype plates of the same page are required, to take a distinct plaster mould for each.

Another plan, which has been tried for the production of stereotype plates too large for casting in the ordinary way, but which has not proved very successful, is to place the mould in a flat iron box, having a trough-shaped mouth at one end, and to pour in the metal with the mould-box, which must be previously heated, in an inclined position. The method of striking the moulds, and from them the plates themselves, by letting the original or pattern types or blocks fall upon a mass of soft metal in a half-melted state, is practised in France, and has been repeatedly tried in this country: it is especially adapted for the production of copies of wood engravings, but it is very liable to injure a delicately engraved block. In this, as in the ordinary casting process, the original engraved blocks should be smeared with some substance that may prevent the cast from adhering to them.

A process of stereotyping, which was several years in attaining its present practical efficiency, has been introduced from Paris. On receiving the type, moistened sheets of unsized tissue paper are laid over it, one above the other, to the number of six or seven, slightly pasted together, and upon these is laid a stouter paper; the whole is then struck with a large flat brush till the softened paper has received a perfect impression of the type. This being done, the paper is removed, placed upon a hot iron table, a blanket laid over it, and screwed down moderately tight, in order to harden it and extract the moisture. The whole operation (paper having been prepared by wetting a few hours in advance) occupies less than an hour. From this mould a stereotype cast can be taken by merely pouring in the molten metal on it when placed in a receptacle, in which a simple contrivance at once regulates the thickness and the size of the plate, that is, how much or how little margin is left outside the type for the purpose of fastening it to the blocks. A couple of hours suffices for the whole process; and it is now adopted upon several newspapers and other publications of large circulation, as many casts can be taken from one mould. A plurality of machines or presses are thus enabled to be set to work for the production of the requisite supply.

Another considerable advantage is, that the moulds may be preserved, so as to be used whenever wanted. It is only necessary that they should be stored so as to be neither too warm, nor too damp, nor too dry, as the paste will ferment, or the sheets crack and separate. With care however they may be kept safe for a considerable time, and thus the locking up of a large amount of metal may be avoided.

The alloys used for various kinds of stereotyping differ slightly in their composition, but generally consist of type metal.

Stereotype-plates need careful examination and *picking*, to remove the imperfections in the casting. Small hollows, such as the loops of an a, an e, or an o, are liable to be filled up with metal, owing to blobs of air in the mould, and the fine white lines in wood-engravings are sometimes filled up. Such matters should be corrected by the picker, who should also cut down, with suitable tools, such blank spaces as might be liable to soil in printing. Before printing, also, defective letters or words which cannot be corrected by the picker should be cut away, and types inserted in their place. These types are soldered into holes drilled through the plate; their stems being sawn off flush with the back.

Although the plates are cast of as equal a thickness as possible, they require, before printing from, to be accurately flattened at the back by means of a peculiar kind of lathe, in which a steel cutter, or *knife*, mounted in a slide-rest, shaves off the metal from the back of the plate in concentric circles, until it is made perfectly even. They are then mounted upon blocks of wood or metal, to raise them to the same height as common types. The tendency of wood to warp when exposed to changes of temperature, or to occasional wetting, has led to many projects for mounting stereotype-plates upon blocks of cement, or upon metallic mounts which might be applicable to plates of various sizes. When wooden blocks are used, the plates are usually secured to them by clips at the edges, and sometimes by screws.

The process of stereotyping is one of the most important means by which the production of cheap books has been facilitated of late years. For a work of limited and temporary demand it is unnecessary; but where the demand is very great, and likely to last for several years, it is all-important, since it enables the publisher to keep up the supply without the expense of having a very large edition printed at once. In most cases where the demand is uncertain, and in almost all where the demand is sure to be large, it is desirable to resort to stereotyping, because, although it increases the first cost of production, it enables the publisher to avoid, on the one hand, the risk of printing a great number of copies which may prove unsaleable, and, on the other, the outlay necessary for the re-composition of the types, in case the demand should exceed the number of copies first printed.

It has often been urged as an objection to stereotype printing that it tends to perpetuate errors; but the fallacy of such a statement may be easily shown. In re-composition new typographical errors are pretty sure to arise, while the expurgation of old ones is by no means certain; but in stereotype plates the occurrence of new errors (excepting by the breaking off of a letter or figure) is impossible, and original errors may be altered whenever they are discovered. Such alterations are not necessarily confined to the insertion of a letter or a word; for whole sentences and paragraphs may be altered in like way, provided that the new matter be made the same in extent as that which is cut away. Hence a stereotyped work may be gradually rendered almost immaculate; and an error which would otherwise have run through the whole edition, may be corrected when only a few hundred copies have been circulated.

The interest connected with the question of *Printing for the Blind*, to which considerable impetus was given by the Society of Arts for Scotland at Edinburgh, who offered their gold medal for the best alphabet for the blind, has tended greatly to bring about a change in the intellectual education of the blind. The publication of the article BLIND in the 'Penny Cyclopædia' at a time when the minds of many were thus directed, and the strictures therein contained on the absence of intellectual training in most of the asylums, also rendered essential benefits on this point. Dr. S. G. Howe, of Boston in the United States, in 1833 contrived an alphabet, founded upon that of Haüy, of a very compact form, in which the New Testament was printed in 1834, and is now in general use in America. The late Mr. John Alston, the treasurer of the Glasgow Asylum, than whom no man connected with the blind deserves more honourable mention, contributed greatly to this educational movement. He saw that, by adopting any character more or less arbitrary, the evil would necessarily follow of isolating the blind by putting them in a position to require special teachers. He therefore adopted the plain Roman characters deprived of their small extremities—the *sans-serif* of type-founders; and, finding that it could be easily read, that it would enable any seeing person who could read to be a teacher of the blind, he at once procured founts of type, and published several works in raised letters; the success of these for their special object established the pre-eminence of his alphabet. Having thus laboured for several years, he visited more than once the principal asylums for the blind in the kingdom. In his work 'Statements,' &c., published in 1846, he says, that after the introduction of his system, "I found a considerable improvement. Subsequently I visited the English institutions a third time, and found a very great number who could read with ease and intelligence; and I have reason to know that there are some hundreds reading these books, and that many families are in possession of the whole of the Bible in raised types: thus in a short time showing the sufficiency of the system placed before the public." It may be added, that Mr. Alston also brought out some beautiful music and maps, and that he published the Old and New Testament in 19 vols., super-royal 4to. The paper used for these works is strongly sized, to retain the impression. In order to account for the great extent of the Bible, it must be borne in mind that the paper can only be printed on one side, and that the letters require to be of considerable size in order to be distinct to the touch. The printing is effected by a copper-plate press. The types being strongly relieved, and liable frequently to give way under the heavy pressure required, it was necessary to have them re-cast four times during the progress of the work. The whole of the works were completed within the walls of the Glasgow Asylum, a man and a boy acting as compositors, there being one pressman, and the ordinary teacher acting as corrector of the press. These books are now used in most of the British asylums for the blind, and also in America. The success which has attended Mr. Alston's exertions was a new assurance to the Society of Arts for Scotland that they had acted wisely in regarding the stenographic and all other arbitrary characters, as well as the angular modifications of the Roman alphabets, unfaveurably.

Nature-printing, also called *Autotypography*, is an invention introduced from the Imperial printing-office in Vienna, by the late Mr. Henry Bradbury. The merit of the discovery has been a matter of contest into which we shall not enter, but we may remark that M. WORRING (in BIOG. DIV.), to whom we have attributed much of it, has disclaimed all beyond carrying into effect the suggestions of Councillor Auer, the director of the Imperial printing-office. The invention successfully pretends to give an exact reproduction of natural objects, such as plants, the grain of wood, &c.; and of other flat substances, such as lace, &c., in a form which enables a large number of impressions to be printed, and in their natural colours. The transference of the forms of plants to paper had been effected even centuries since, either by staining the plants, or by simple pressure. In this manner, however, the object, after taking a few impressions, was rendered useless. At Vienna the art was rendered more perfect by taking an impression on polished lead, from which impressions could be printed, though still in only a very limited number. Softened copper-plates were then adopted, which were found equally capable of receiving the impression, to its minutest markings, of the substance pressed on it. The object is arranged on the plate in the desired form, and is then subjected to an enormous pressure for a sufficient time, when it is found that the object has left its form deeply impressed upon the plate. This plate is subsequently hardened, and is fitted to furnish a large number of impressions. The plates are coloured, or inked as it is termed, with the proper colours of the plant, which is easily done, as the face of the plate is wiped after each colour has been laid on; the paper is laid upon the plate and passed through a press formed of two cylinders pressing against each other, of which one is covered with thick blanketing. and with a regulated pressure, the impression is produced in a low relief. In Vienna, several works of a magnificent character have been produced. In England there have been three, 'The Ferns of Great Britain;' 'British Sea Weeds;' and 'Trees of Great Britain;' all of which possess a high degree of excellence as works of art, and are of course of unexceptionable correctness.

Electro-printing.—The processes of the "Electro Printing-Block Company" (patented by Mr. H. G. Collins) supply the means of reproducing drawings, engravings, &c., without the aid of copyist or engraver, not only of the same size as the original, but enlarged or reduced with strict accuracy to any extent that may be desired. Thus, from a woodcut or steel engraving, say of 6 inches by 4, a working plate or block can be produced that will yield impressions 12 inches by 8, or 3 inches by 2, or of any other required proportion. We will briefly describe the beautifully simple means by which this is effected, and then indicate a few of its actual or probable applications.

The whole, in fact, depends on the capacity of india-rubber for extension in any direction, and its property of returning to its original size when the tension is removed. Let us suppose that it is desired to obtain an *enlarged* copy of an engraving. The surface of a sheet of galvanised india-rubber, the size of the print, is covered with a film of an elastic composition, and upon this film, when dry, an impression of the print is taken by means of transfer ink. The sheet so printed upon is then placed in a rectangular steel frame, hooks from the sides of the frame passing through holes pierced at equal intervals in the edges of the india-rubber. By a simple but ingenious double screw action, two opposite sides of the frame are now gradually drawn apart, till it is seen, by a scale engraved on the sides, that the india-rubber sheet is sufficiently extended. The same is done with the other two sides; and the whole having been carefully examined to see that the enlargement is uniform, the frame is fixed, in order that the strained sheet may not be in any way disturbed during the next operation. The impression thus enlarged on the india-rubber is now transferred by the ordinary lithographic transfer process to a lithographic stone, or zinc plate, which, after the usual treatment [LITHOGRAPHY], yields impressions exactly like any other prepared lithographic stone.

For a *reduced* copy, the only difference in the process is, that an india-rubber sheet of the desired size is strained to the dimensions of the print to be copied, before the impression is placed upon it, and then allowed to contract to its original size, when the impression is transferred to the stone. It ought perhaps to be mentioned that first of all the india-rubber sheet has printed upon it thin lines, which divide its whole surface into squares of a quarter of an inch each, thus affording, by means of the T square and compasses, an easy means of detecting the slightest inequality of extension in any part during the process of enlarging, whilst the frame is so constructed as to permit any deviation to be at once remedied.

For obtaining blocks for *surface-printing*, an additional process is required. After the enlarged (or reduced) impression is transferred to the lithographic stone or zinc plate, the surface of the stone or zinc is exposed to the action of an acid, which eats away all the parts not protected by the ink. The print is thus left in raised lines corresponding to those of an engraved wood-block. A matrix is taken in some suitable material, and upon this a cast, corresponding to the original wood-block, or a stereotype from it, is formed by the ordinary method of electrotype deposit. [Electro-Metallurgy.]

The processes we have described suffice for all the usual purposes of lithographic printing, and printing by the ordinary type-press. To both there are limitations within which only success can be at present assured. Mezzotint, or finely stippled plates, for instance, cannot be successfully reproduced; but ordinary steel plates, wood-cuts, music, maps, and plans, can be enlarged or reduced with minute accuracy, and printed as lithographs with perfect certainty. The surface-block is somewhat less certain; but very beautiful results have been obtained, and the manipulative difficulties appear in a fair way of being overcome.

The further applications of the process seem almost illimitable. For surveying and engineering purposes, for example, a sheet of the Ordnance map could be taken, and in a few hours a copy be produced large enough to admit of the insertion of any amount of local detail. For the potter's use, from a single small drawing or print of a pattern, copies to any extent may be produced, to suit the various sizes of all the articles of a tea- or dinner-service; and if the original pattern be circular, it may be altered to an oval for dishes, &c. Its application to various other branches of ornamental art and manufacture, where variations of the size or form of designs are required, is obvious: whilst in fine art, the small pen or pencil sketch of an artist may at once, by mere mechanical means, be reproduced as a good-sized lithograph; the original study of a painter, if he choose so to work, be enlarged ready to his hand on his canvas, preparatory to painting; the diagram of the man of science speedily be reproduced of a size suitable for the lecture-room. Another application which the process is said to be already quite capable of carrying into practice is, that of reproducing impressions (of course of any size required) of books or engravings, even though a couple of centuries may have elapsed since they were printed. And any of these applications of the method is obtainable at a comparatively small cost.

PRINTING, CALICO. [Calico-Printing.]

PRIOR, PRIORY, ecclesiastical terms denoting certain monastic foundations and the heads of such foundations. They differ in nothing essentially from the terms abbot and abbey. There were in England religious houses the chiefs of which were called priors, quite as rich and as powerful as many that had a chief who was called the abbot. Thus in Yorkshire there were two houses at no great distance from each other, called Roche and Nostel, the head of the former being an abbot, and of the latter a prior, though Nostel was the more ancient and more considerable foundation. The prior of St. John of Jerusalem was equal to any abbot; yet in the main we find the greater monastic foundations presided over by monks who were called abbots. In some cases there was both an abbot and a prior, when the abbot was regarded as the superior officer; and in the priories there was often a second officer called the sub-prior.

PRIORITY. [Notice.]

PRISM (πρίσμα), in Mathematics, is a solid formed by a straight line which moves parallel to a given straight line, and one end of which traces out the contour of a given rectilinear polygon. The other extremity of the moving straight line traces out an equal and similar polygon, placed parallel to the former one: and the prism is thus bounded by two equal and parallel polygons, joined by as many parallelograms as each polygon has sides. When these parallelograms are at right angles to the planes of the polygons, the solid is called a right prism; in all other cases, an oblique prism. The prism is among plane solids what the cylinder is among curvilinear ones: it is also called triangular, quadrangular, pentagonal, &c., according as the polygons have three, four, five, &c., sides. Thus the prism used in optics is a triangular prism, while the parallelopiped is a quadrangular prism.

The number of cubic units in the contents of a prism is found by multiplying the number of square units in either of the polygons by the number of linear units in the perpendicular distance between the planes of the two polygons; and all prisms, however much they may differ in obliquity, which have equal bases, and equal heights or perpendicular distances between opposite polygons, are equal in magnitude.

No other rule can be given for computing the surface of a prism except the simple direction to add the areas of the two polygons to those of the joining parallelograms. But in the case of a right prism, the finding of the parallelograms may be shortened by multiplying the number of linear units in the contour of one polygon by the altitude of the prism.

PRISM. [Optics; Refraction.]

PRIVATE ACT. [Parliament.]

PRIVATEER, a private ship of war, fitted out at the cost of an individual for the purpose of carrying on hostilities on his own account, but under the sanction of a belligerent state, against the public enemy. It is the practice of most nations to commission vessels of this kind as auxiliaries to the public force. The owners of them are licensed to attack and plunder the enemy, and their enterprise is encouraged by allowing them a large portion of any property they may capture. By the law of nations they are not considered pirates. It is usual for the country on whose behalf they carry on war to take security for their duly respecting the rights of neutrals and allies, and observing generally the law of nations. [Prize.] (45 Geo. III. c. 72; 1 Kent's 'Commentaries,' 96.)

PRIVILEGE (*Privilegium*, from the sense of which however it has been perverted), a particular beneficial exemption from the general rules of law. Privilege is of two kinds; *real*, attaching to place, and *personal*, attaching to persons, as ambassadors, peers, members of parliament, attorneys, &c., whose peculiar privileges are stated under these heads respectively.

Formerly many places conferred the privilege of freedom from arrest, even in criminal matters, upon those entering them [Sanctuary]; and even in later times many places existed which privileged those within them from arrest in civil suits. Of these the most notorious were White Fryars, the Savoy, the Mint, and other places in their neighbourhood. But by 8 & 9 Wm. III. c. 27, the privileges of all these places were abolished. However at the present time, no arrest can be made in the king's presence, nor within the verge of the palace of Westminster, nor in any palace where he resides, nor in any place where the king's justices are sitting. (3 'Inst.,' 141.) Personal privilege, conferring freedom from arrest, is enjoyed by all suitors, counsel, witnesses, or other persons attending any courts of record upon business, or an arbitrator under a rule of Nisi prius. This exemption is to be interpreted liberally, and will not therefore be forfeited by taking refreshment after a suit, or by going other than the direct road to or from a court. (Com., 'Dig.,' tit. Privileges.)

PRIVILE'GIUM. [Law.]

PRIVY COUNCIL (Consilium regis privatum, concilium secretum et continuum concilium regis). The privy council, or council table, consists of the assembly of the queen's privy councillors for matters of state. Their number was anciently about twelve, but is now indefinitely increased. The present usage is, that no members attend the deliberations of the council who are not especially summoned for that purpose. They must be natural-born subjects of England, and are nominated by the crown without any patent or grant. After nomination and taking the oath of office, they immediately become privy councillors. Formerly they remained in office only during the life of the sovereign, who chose them subject to removal at his discretion; but by 6 Anne, c. 7, the privy council continues in existence six months after the demise of the crown, unless sooner determined by the successor, and they are to cause the successor to be proclaimed. The privy council of Scotland is now merged in that of England, by 6 Anne, c. 6. The duties of a privy councillor, as stated in the oath of office, are, to the best of his discretion truly and impartially to advise the king; to keep secret his counsel, to avoid corruption, to strengthen the king's council in all that by them is thought good for the king and his land, to withstand those who attempt the contrary, and to do all that a good councillor ought to do unto his sovereign lord. By the Act of Settlement (12 & 13 Wm. III. c. 2) all matters relating to the government properly cognizable in the privy council are to be transacted there; and all the resolutions taken thereon are to be signed by such of the privy council as advise and consent to them.

The court of privy council is of great antiquity; and during earlier periods of our history appears not always to have confined itself to the entertainment of mere matters of state. It had always and still has power to inquire into all offences against the government; but it often assumed the cognizance of questions merely affecting the property and liberties of individuals. This is evident from the complaints and remonstrances that so frequently occur in our history, and ultimately from the declaratory law of the 16 Chas. I. referring to such practices. Probably the very statement of Sir Edward Coke, that the subjects of their deliberation are the "publique good, and the honour, defence, safety, and profit of the realm .... private causes, lest they should hinder the publique, they leave to the justices of the king's courts of justice, and meddle not with them," proceeded from his knowledge that such limits had not always been observed, and his jealousy of their invasion. Several other passages in his works seem to show that this was so. The attempts to enlarge the jurisdiction of the council appear always to have been resisted as illegal; and they were finally checked by the 16 Chas. I. c. 10. That statute recites that of late years "the council-table hath assumed unto itself a power to intermeddle in civil causes, and matters only of private interest between party and party, and have adventured to determine of the estates and liberties of the subject, contrary to the laws of the land, and the rights and privileges of the subject." By the same statute it is declared and enacted that neither his majesty nor his privy council have or ought to have any jurisdiction in such matters, but that they ought to be tried and determined in the ordinary courts of justice, and by the ordinary courts of law.

Subsequently however to this statute, in matters arising out of the jurisdiction of the courts of the kingdom, as in colonial and admiralty causes, and also in other matters, where the appeal was to the king himself in council, the privy council continued to have cognisance, even though the questions related merely to the property of individuals. By 2 & 3 Wm. IV. c. 92, the powers of the high courts of delegates, both in ecclesiastical and maritime causes, were transferred to the king, in council. The decision of these matters being purely legal, it was found expedient to make some alterations in the court, for the purpose of better adapting it to the discharge of this branch of its duties. Instances had before occurred where the judges had been called in and had given extra-judicial opinions to the privy council; but the practice was inconvenient and unsatisfactory, and all necessity for it is now wholly removed. By the 3 & 4 Wm. IV. c. 41, the jurisdiction of the privy council is further enlarged, and there is constructed from it a body entitled "the judicial committee of the privy council," which now consists of the keeper of the great seal, the chief justices, the master of the rolls, the chief baron, and other great judicial officers. Power is also given to the king by his sign manual to appoint any two other persons who are privy councillors to be members of the committee. The same powers for enforcing their decrees, &c., are given to the judicial committee as are possessed by the Court of Chancery, Queen's Bench, &c.

The privileges of a privy councillor, beyond those of mere honorary precedence, formerly related to the security of his person. If any one struck another a blow in the house or presence of a privy councillor, he was fineable. Conspiracy by the king's menial servants against the life of a privy councillor was felony, though nothing were done upon it. And by 9 Anne, c. 16, any unlawful assault by any person on a privy councillor in the execution of his office was felony.

These statutes have however been now repealed, by 9 Geo. IV. c. 31, and any offence against a privy councillor stands on the same footing as offences against any other individual. (1 'Co. Lit.,' 110, a. n. 5; 3 'Inst.,' 182; 4 'Inst.,' 52; 1 'Blackst. Com.' Mr. Kerr's edit., ch. 5; Hallam's 'Constitutional History.')

PRIVY SEAL. [SIGN MANUAL.]

PRIZE, property taken from an enemy at sea, the law as to which is regulated by the general law of nations. As between the belligerent powers themselves, the property in a ship or other thing captured passes at once, by the mere taking itself, to the captor. But the thing captured may be purchased from the captor by a person belonging to a neutral state, or it may be recaptured. It becomes therefore necessary, as between the original owner and such purchaser, or between the original owner and the recaptor, to lay down some rule for determining at what time and under what circumstances the thing captured becomes prize, so that the property in it passes to the captor for all purposes. The law of nations upon this point was very vague and unsettled. It used to be said that property was not devested by capture until after possession had been retained twenty-four hours, or until the prize had been taken infra præsidia; or again, until the spes recuperandi was gone. The present rule is thus expressed by Lord Stowell:—"By the general practice of the law of nations a sentence of condemnation is at present deemed generally necessary, and a neutral purchaser in Europe during war looks to the legal sentence of condemnation as one of the title-deeds of a ship, if he buys a prize vessel." Sentence of condemnation, that is, sentence that the thing captured is prize, and that consequently the property of the original owner in it is entirely devested, must be pronounced by a court of the capturing power duly constituted according to the law of nations. The prize court of the captor may sit in the territory of an ally, but not in that of a neutral. Questions of prize are by the English law disposed of in the courts of Admiralty. [ADMIRALTY.] (45 Geo. III. c. 72.)

PRIZE-MONEY. All the acts relating to army prize-money have been repealed by the 2 & 3 Will. IV. c. 53, which also enacts that all captures made by the army shall be divided according to such general rule of distribution as the king shall direct.

PROBABILITY, PROBABILITIES, THEORY OF. A conclusion is said to be known in two distinct ways; first, when it is derived from those principles (as we call them) which may be considered as common to all mankind, or which at least no one is found to deny; secondly, when it results, by a sure process of inference, from premises which are believed to be known. Whether these premises be properly known, that is to say, whether another person assuming to decide on the propriety or impropriety will be satisfied or not, is not a part of the present inquiry. That knowledge of the first kind exists is unquestioned, and most of the results of such knowledge are agreed upon. That knowledge of the second kind exists is also unquestioned, though two men may differ as to whether a given conclusion be part of it or not. The distinction, as elsewhere noticed [MATHEMATICS], is positive, easily apprehended, and useful; it exists moreover, and must exist, whatever may be the system of psychology on which one man or another may explain it.

In the exact sciences, demonstration is always effected in such a way as to show that nothing contradictory of the proposition demonstrated either is true or can have been true at any time. Two sides of a triangle are, were, and always will be, greater than the third; by which we mean that persons with minds constituted as ours are, must have admitted this, must now admit it, and must admit it in all time to come. Those who should deny the proposition must really hold that a whole may be less than its contained part: such is the alternative which geometrical demonstration offers for acceptance, and we should cease to consider a mind as the proper object of instruction which should prefer the alternative to the proposition. Such truths as these are not the subject of the present article.

The other class of conclusions consists of those which may be false, or which may have been false at one time, or may become so, without the necessity of our supposing an absolute and inconceivable difference of mental constitution between ourselves and the person who may have seen this falsehood, may now see it, or is to see it. Many such conclusions appear to be as certain as if they were absolutely demonstrated, until a close and (to those who have not considered the subject) a captious test is applied, which shows that this certainty is not what is called mathematical certainty. One of the most certain perhaps of all is this: a ball of iron suspended by a thread will fall to the ground when the thread is cut; every one is as well persuaded of this truth as of the two sides of a triangle being together greater than the third; those who have not studied geometry know the former much better than the latter. But let any one assert that he has seen, in a part of Africa unexplored except by himself, a ball of iron suspended in the air, which, though iron to the sight and touch and iron to every *chemical* experiment, not only remains in the air without support, but, when forced to the ground, rises again of itself to the same height. We should laugh and disbelieve it, but we could not disprove it; in spite of our laughter and unbelief, no man can know such a thing to be false. Let a number of credible persons solemnly declare that they have seen the same phenomenon, and our unbelief would be shaken: finally, let it be a matter, as it is called, of common notoriety, and let a continual succession of good witnesses passing and repassing constantly confirm each other in the recital above mentioned, and our positive disbelief would be changed into as positive a belief. But let a new witness declare that the natives use bows and arrows of the common form, in which the straight string of the bow, meaning that part of it which joins the extremities of the bow, is four or five times as long as the curved bow itself; though our disbelief of this first witness would not be sensibly stronger than our disbelief of the first witness in the preceding case, yet it must be of this kind, that any succession of respectable witnesses, however numerous, could never add any force to the fact in a mind which can properly appreciate the grounds of the assertion that a straight line is the shortest distance between two points. A million of witnesses could do no more than one to establish the fact stated, in the mind of a person who knows what geometrical demonstration is; though it is just possible that another, who only learns the connection of the sides of a triangle from experiment, may be capable of being convinced of the second assertion by evidence, as well as of the first.

The *probability* of an asserted fact or conclusion means, in common language, the degree of belief which we think we ought to accord to it, and it depends in each mind upon the amount of evidence offered, the degree in which that evidence is understood, the fitness of that mind to receive and be acted on by evidence, and in particular by the evidence which is offered. Evidence insufficient, or ill understood, or offered to a mind which is unduly credulous or sceptical, whether to the particular sort of evidence in question or to evidence in general, may give a low degree of probability, or none at all, to what another mind considers as indisputable; or the contrary. In the common use of the word, a result is said to be probable only when the mind inclines more or less to believe it, and improbable in the contrary case. The mathematical use of the term is rather different; but, till further notice, we retain the common signification.

We are going to treat belief as a QUANTITY, not only to speak of its more and less, but to submit that more and less to measurement. The phrase is unusual, but when a halfpenny is in the air, we half believe that *head* will fall uppermost, and we half believe in *tail;* this is what we mean when we say the chances are even. But the reader must remember that in our present subject belief does not mean that result of self-will which a person puts forward as his *opinion.* Without any wilful falsehood, men can contrive very frequently to disguise the real state of their minds with respect to a proposition, and to substitute their wishes for their beliefs; not their prejudices, for real prejudice *is* belief, but their wishes. The conclusion of the mind is thrust into a corner; and when, after all, it is necessary to declare it, we hear—I had all the time a *lurking* belief, &c. That lurking belief was the rightful owner, but the sovereign will had put a usurper in his place. The verb to *believe* has only one future form; what we shall believe, and what you will believe, are legitimate matters of conjecture. But "I will believe" is a declaration which is no more in our own power than "thou shalt believe" is in our own right. It has cost England centuries of struggle to tear the second out of the grammar of statesmen and divines; but how much longer it will take to get as well rid of the first is beyond the theory of probabilities to guess.

We mean by evidence, in the present inquiry, not merely oral or written testimony, but everything which disposes the mind, however little, to adopt or reject, including even the effect of previous knowledge. The value of evidence, that is, the extent it should go towards inducing belief, is really the subject of inquiry in a branch of exact science known by the name of the *theory of probabilities*. But how can the value of evidence be made a subject of measurement? why can this be done in the case of an amount of credibility more than in that of an amount[*] of benevolence, courage, or talent? We should assuredly think any one must be in a curious delusion who should suppose himself to have ascertained, from the data given by Homer, that the warlike skill of Achilles was exactly 552 times that of Thersites, and that Shakspere had done the former a foul wrong, for that he had made it only 237 times and a fraction. But what is the difference, in the nature of the inquiry we seek to institute, between attempts to measure prowess and probability? On the mode of answering this question it depends whether we are to make our subject merely, as heretofore, a kind of artificial method of judging the chances of a game of hazard; or a rational and exact mode of doing, when data are sufficient, that which we daily attempt to do, as well as we can, with our inaccurate appreciations of the circumstances of common life; and a science to be used, as are others of a mathematical nature, for accustoming ourselves to estimate or guess with something like accuracy, by habitual acquaintance with cases in which absolute accuracy is attainable.

When we consider all the circumstances which affect belief or opinion, both those which are external and those which depend on the mind which is exposed to them, it may well bewilder the imagination of a person not accustomed to the idea, when he hears of an attempt to reckon credibility in numbers, and to deduce what are called exact conclusions from hypotheses as to the force of assertions. To remove from the threshold of the subject the incredulity which must exist, and ought to exist in the first instance, let us suppose the other branches of science presented to a student not in their simple beginnings, but by a description of their ultimate physical objects. To put this beginner in a state parallel to that of readers in general with respect to the subject of probabilities, he must be of mature age, with very little knowledge of number, none of any other branch of mathematics, and no conception of the construction or use of any physical instrument, nor of the object and procedure of any one experiment. He might then be addressed as follows:—"You are, without moving from this earth, to track the motions of all the heavenly bodies, to be able to ascertain where they were or will be at any moment of time past or future, to measure their sizes, to weigh their contents, and to find the species and amount of insensible forces which, by some unknown means, they exercise on one another. You are to detect the existence of a subtle fluid which can neither be seen, heard, nor felt, to measure vibrations of which there are millions in a minute, and to trace the course of effects which travel hundreds of thousands of miles in a second. You are to weigh against each other atoms of matter of which it cannot be shown that millions put together would be visible to the eye." The person so addressed would not be less bewildered nor more disposed to treat the proposed results as fictions, than he who hears for the first time of a numerical theory of probabilities. But let us now reverse the method, and suppose the learner allowed to begin at the beginning. He first finds that, step by step, his rude notions of number are organised into a method of computation which enables him easily to perform more than he could have imagined the most subtle brain to have devised. From notions of the simplest kind connected with space, properties of figure become almost intuitive, of which he could at one time not have comprehended the description, far less the demonstration. By reasoning on the simplest properties of matter, such as can be proved to his senses, he finds no difficulty in tracing remote and complicated combinations of effects from the plainest causes, by which he learns to invert this process, and to reduce observed combinations to their simplest elements. But if, during this long and very gradual process, he were to keep continually before his mind those great results the knowledge of which he had been promised, looking to arrive at the fulfilment of the promise by some sudden acquisition of power, his whole course would be one of disappointment. He would be peeping forward a few pages in his Euclid, in the hope of seeing himself almost arrived at the means of calculating an eclipse or explaining the theory of colours, and would find that he was to learn how to make a square equal to a given figure instead.

Now the application of the preceding description to our present subject is as follows:—The beginner in exact science has usually no definite notions as to the end which he is to arrive at; nor do the terms algebra, geometry, mechanics, &c., suggest any associations beyond a vague notion that they are parts of a learned system. But it is impossible that the beginner in the subject of this article should be without an explicit and probably an exaggerated notion of what he is to attain. There is no unknown Greek or Arabic term the meaning of which must be slowly learned by the study of the science of which it is the name; the word *probability*, so well known in the common affairs of life, stares him in the face at the head of every page, and reminds him to be dissatisfied with the extent of power gained, up to the point at which he has arrived. Unless then he can make up his mind to descend, as a student would do who, having in his head the theory of gravitation and the laws of light, should lay by these grand ideas, and set himself to trace the consequences of the simple notion that two straight lines cannot enclose a space—he must be warned that he will be likely to quit the subject in disgust. We now proceed to the fundamental points of the theory.

That opinion may be formed with more or less strength, particularly when the subject-matters are of different species, is well known to every one from his own experience. The most decided republican in England, for instance, is not so sure of the wisdom of the Long Parliament as he is that all its members are now dead; and no royalist, however well persuaded of his tenets, thinks the Restoration was of as much consequence to this country as sun, wind, and rain. It matters nothing that the different degrees of assurance refer to very different matters, and are obtained in very different ways; that they are separate amounts of the same kind of feeling is universally felt and admitted. To make something like a gauge for these degrees of belief is not difficult; to apply it is a harder task, seeing that the cases which present circumstances of sufficiently definite character are seldom met with.

Suppose a box to contain 3 white and 4 black balls; it is easily admitted that it is more likely that a black ball should be drawn than a white one, on the supposition that the drawer does not see the balls. Or rather we should say it is easily admitted that every well regulated mind *ought* to think a black ball more likely than a white one: and that if any one should imagine the contrary, he has formed an opinion from prejudice, fancy, or want of proper consideration. Just as we should say that if all the balls were black, a black ball would certainly be drawn, so when a majority of the balls is black, and each one ball is as likely to be drawn as any other, there are more ways of drawing black than white, and we look upon the former as more obtainable, and more likely to be obtained, than the latter. Common experience makes us consider the black as more likely than white, when the number of black balls is much greater than that of white balls; as, if there were only 3 white balls, and a million of black ones. Here, as in other questions of magnitude, we can see a difference when the difference is great, which we must perhaps learn to see when it is small: it is plain enough that the black is more likely than the white when there are a million of black balls to one white; but not so easily grasped that the black is more likely than the white when there are five hundred thousand and one black balls to five hundred thousand white.

The next step to be made is the assertion that when there are 3 white and 4 black balls, the probability of drawing white is to that of drawing black in the proportion of 3 to 4; that is, if we could by a voluntary act make our impressions about the probability of future events of that strength which our reason tells us they ought to have, we should choose to expect a black ball more strongly than a white one in the proportion of 4 to 3. The principle on which we do this is the main point of the theory, the only objectionable part, if there be one: for all the rest is mathematical deduction.

The principle is as follows:—When any number of events, A, B, C, &c., are such that one and only one can happen at a time, and when *a*, *b*, *c*, &c., are the numbers of ways in which they can severally happen, the probabilities of the several events are in the proportions of the numbers *a*, *b*, *c*, &c. Returning to the preceding simple instance, we have an obvious negative reason for supposing that the probabilities should be as 4 to 3, since there is no imaginable ground for assuming, while the excess of black balls is the sole cause of the superior probability of drawing one of them, that this excess of probability should be in any other proportion than that of the excess of black balls. If we grant the following, namely, that the probability of having one or other out of two of the different results which a trial may give, is, or ought to be, the *sum*[*] of the probabilities of the two separately, we shall be obliged to admit positive reason for the preceding principle, as follows:—Suppose a box to contain 10 balls, marked 1, 2, &c. up to 10, and no others. A ball is to be drawn, and the drawer has in his mind an amount of hope, fear, or simple admission of possibility, as the case may be, as to the happening of each number. If the drawing of No. 1 be to gain him a prize, there is a certain amount of hope; if it be to procure him a loss, of fear; if neither one nor the other, of feeling that No. 1 may be that which is drawn. Now let either 1 or 2 bring the gain or loss; is the feeling of hope or fear doubled in strength? or rather, *ought* it to be doubled? He who admits this, admits the whole theory of probabilities, for all the rest is mathematical deduction. Let x be the proper numerical measure of the probability of drawing 1, or of drawing 2, &c.; these probabilities being equal, since there is, by the hypothesis, nothing to render one more likely than the other. Then, if the preceding be admitted, $2x$ is the probability that either 1 or 2 is drawn; $3x$, that either 1, 2, or 3 is drawn; and so on up to $10x$, which is the probability that one or other of the set 1, 2, 3, ... 10, shall be drawn. But since that a drawing shall take place is an absolute condition, one of the ten numbers must be drawn; hence x must be so taken that $10x$ shall be the numerical measure of certainty. It is indifferent what number is taken to stand for the exponent of certainty, so far as principles are concerned; but in a mathematical point of view, unity is more convenient than anything else. Let unity be adopted, then $10x=1$, or $x=\frac{1}{10}$. Hence the chance of drawing, say one of the three, 1, 2, 3, is $\frac{3}{10}$; and that of drawing one of the remaining 7 is $\frac{7}{10}$. If then the first three should be white balls, and the last seven black, the chance of a white ball is $\frac{3}{10}$, that of a black one is $\frac{7}{10}$; and a black ball is more likely than a white one in the proportion of 7 to 3, which being inequality in the proportion of 2⅓ to 1, the *odds* are said to be 2⅓ to one in favour of a black ball, or against a white one. By this we do not mean that every man *does*, in such a case, look for a black ball with an expectation 2⅓ times as great as his expectation of a white ball, but that, if he *could* measure the strength of his own feelings and adjust them with mathematical precision, he *would* proportion the strength of the two expectations in the preceding manner. And if money were to be spent upon the expectations, he may as reasonably give 2⅓*l.* for a black ball, before it appears, as 1*l.* for a white one. We do not naturally reckon probabilities by numbers; but nevertheless, we have some kind of estimating apparatus in our brains: Kant called it *a weighing machine with unstamped weights.*

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[*] It is rather for the argument that we endeavour, however imperfectly, to make numerical standards of use in estimating every one of these qualities, which we put down at hazard before the matter of this note suggested itself. We are apt to compare the benevolence of two persons by the pecuniary results of their liberality; confounding the two qualities, but perhaps the very confusion arises partly from the numerical measure which is thereby supposed attainable. We form a vague notion of the comparative courage of two soldiers, by comparing the different amounts of danger which we think they have faced; a most unfair and fallacious test, but still indicative of the tendency to measure. Finally, we compare talent in what, speaking of the way it is now done, we can hardly call a more rational manner, by trials of what competitors can do under the same circumstances and in the same time.

[*] Disjunctive mention is a logical aggregation, a summation, of classes. When we say "He is either fool or mad," we say he belongs to the genus which contains the species *fool* and *mad*. To describe him in a word, we want a name for fool + mad. We never say "it is either man or brute;" we say "it is *animal*."

It thus appears that the theory of probabilities is simply the reduction to a numerical estimation, in cases which are perfectly known as to the number of events which may happen, of our comparative right to expect one or another event in preference to the rest. In the events of common life, we make estimations of this comparative right, but not *numerically*, because we are not in sufficient possession of the events which might have happened instead of the one which does happen. In such terms as barely possible, very unlikely, improbable, not improbable, as likely as not, rather likely, highly probable, almost certain, &c., we see a gradation which amounts to a rough attempt to make those comparisons which might be made numerically if the proper data could be obtained. The truth is, that every one naturally admits and practises the fundamental principles of this theory, though often, it may be, unskilfully. But it is not to be imagined that persons in general make an investigation like the preceding, nor indeed any investigation at all: how is it then that not only are these principles acquired, however imperfectly, by the majority of mankind, but the mathematical results which are obtained by those who professedly study the subject, are received almost universally; not only are they felt to be agreeable to common sense in a great majority of cases, but they are soon admitted to be sufficient indications that common sense is wrong, in the few cases in which they at first appear repugnant to it? The answer to this question leads to another view of the subject.

We all find, by every-day observation, that whenever an event of one kind happens permanently more often than one of another kind, there exists some reason for such frequency of occurrence, which, had it been inquired into before any event happened, would have enabled us to predict the frequency in question. So much is this the case, that if we were to take an observer to an urn in which were black and white balls, but how many of each he is not told, and were to make 1000 drawings, replacing the ball drawn after each drawing, and shaking the urn before every trial; if of the thousand drawings 822 were white and 178 black, he would be irresistibly led to conclude that there must be more white balls than black ones in the urn. Not that this is absolutely necessary; for it is barely possible that there may be only one white ball and 999 black ones, and that by a remarkable coincidence the sole white ball may have come up 822 times out of the 1000 trials. More than this, a person used to observation would conclude, not only that there are more white balls in the urn, but that the proportion of white and black balls does not differ very greatly from that of 822 to 178. There is a disposition, derived from experience, to think that events happen in the long run in some sort of manner connected with the facilities afforded for their happening beforehand: and hence follows a disposition to judge what those facilities were from observed events, as well as to predict events from observation of those facilities; and it may happen that one person would draw his notion of likelihood from the first, and another from the second. Thus, if we were to put the question, "What do you mean by saying that it is 5 to 3 for A against B?" one person might reply, "I mean that in the long run A will happen 5 times for every 3 times which B happens;" while another might say, "I mean that precedent circumstances are so arranged that for every three contingencies under which B may happen, there are 5 under which A may happen." If these two persons were to dispute which was the *true* mode of viewing the subject, they would be fighting about nothing; for both are true, and each of them follows from the other: but if they were to differ as to which is the *common* mode, we should feel rather disposed to side with the one who was for the first answer.

The following problems, illustrative of the connection between the two modes, are the results of mathematical investigation. The table used is that given in MEAN: but two decimal places must be made in column A, and four in column B; thus 451 opposite to 4 must be read as ·0451 opposite to ·04, similarly ·8931 comes opposite to 1·14, and ·9825 opposite to 1·68.

PROBLEM 1.—The probabilities of P and Q, at any one trial, are as a to b, that is, it is a to b for P against Q, and b to a for Q against P. A large number of trials $n(a+b)$ is made; what are the chances that the number of Ps which happen shall lie between $n\,a+l$ and $n\,a-l$, and (of course) the number of Qs between $n\,b-l$ and $n\,b+l$ (l being small compared with $n\,a$ or $n\,b$)?

RULE.—Calculate $(2\,l+1)\div\sqrt{\left(\frac{8\,n\,a\,b}{a+b}\right)}$; let this be the A of the table (altered as above); then the corresponding B, altered as above, is the probability required.

EXAMPLE.—It is 2 to 1 that a throw with a die shall give 3, 4, 5, or 6, and not 1 or 2; what is the chance that, in 12,000 throws, the number which gives 3, 4, 5, or 6 shall lie between 8000+100 and 8000−100. Here $a=2$, $b=1$, $n=4000$, $l=100$, and the complete calculation by logarithms* (which we insert merely as a guide to the readiest mode of treating more complicated cases) is as follows:—

$$\begin{array}{lrr@{\qquad}lr}
n=4000 & & 3{\cdot}6021 & 2\,l+1=201 & 2{\cdot}3032 \\
a= & 2 & {\cdot}3010 & & 2{\cdot}1646 \\
b= & 1 & {\cdot}0000 & & \overline{} \\
 & 8 & {\cdot}9031 & \quad 1{\cdot}376 & {\cdot}1386 \\
 & & \overline{4{\cdot}8062} & & \\
a+b=3 & & {\cdot}4771 & & \\
 & & \overline{2)4{\cdot}3291} & & \\
 & & \overline{2{\cdot}1646} & &
\end{array}$$

In the table, A being 1·38, B is ·9490, which is more than near enough for the purpose, say ·95: the result then is that ·95 is the chance in favour of the throws which give 3, 4, 5, or 6 out of 12,000 throws lying between 8000+100 and 8000−100, whence ·05 is the chance against it; that is, it is about 95 to 5, or 19 to 1, that the throws shall so lie. A few instances of this kind will show how completely, in the long run, events may be expected to happen in numbers nearly proportional to what are called, when the precedent circumstances are fully known, their probabilities of happening.

PROBLEM 2.—In the preceding problem, to find l so that there may be a given probability that the Ps shall lie between $n\,a+l$ and $n\,a-l$.

RULE.—Reduce the fraction which represents the given probability to a decimal fraction, and take the A corresponding to the B which is nearest to this fraction in the table; multiply by the square root above described, subtract 1, and divide by 2; the whole number nearest to the result is the answer required for l.

EXAMPLE.—In the preceding example, find l so that it is an even chance that the number of throws out of 12,000 which give 3, 4, 5, or 6 shall lie between $8000-l$ and $8000+l$. Here ½ or ·5 is the given probability, the nearest to it in column B is ·5027 to which A is ·48, which multiplied by the square root (or the number whose logarithm is 2·1646) is 66·9: subtract 1 and divide by 2, which gives 33 very nearly: hence it is an even chance (very nearly) that the number of throws out of 12,000, which give 3, 4, 5, or 6 lie between 8000−33 and 8000+33.

PROBLEM 3.—In $a+b$ trials, a and b not being small numbers, and nothing whatever being known except what these trials tell, it is found that P happens a times, and Q happens b times; from which it is exceedingly likely that the probabilities of P and Q happening at a single trial would have been nearly as a to b, if we had known enough to form an *à priori* opinion. This we cannot do, by hypothesis: but, judging from the preceding events, with what degree of probability may we infer that if we had been able to form an *à priori* opinion, the odds for P against Q would have appeared to us to lie between $a-k$ to $b+k$ and $a+k$ to $b-k$?

RULE.—Calculate $k\div\sqrt{\left(\frac{2\,a\,b}{a+b}\right)}$; let this be A (in the table): then the corresponding B is the probability required.

EXAMPLE.—In 600 drawings from an urn, the ball being replaced after each drawing, there were 418 white balls and 182 black ones. What is the probability that the proportion of white and black balls in the urn lies between that of 418−10 to 182+10 and 418+10 to 182−10, or that of 1000 to 471 and 1000 to 402? Here $a=418$, $b=182$, $k=10$; the square root above mentioned has 1·2021 for its logarithm, and 10 divided by this square root gives ·63 nearly. And A being ·63, B is also ·63 very nearly, which is the probability required; or it is 63 to 37, or nearly 2 to 1, that for every 1000 white balls in the urn, there are between 402 and 471 black ones.

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* In this, and many other cases, the four-figure logarithms, published by Taylor and Walton on a card, will be found by far the most convenient.

PROBLEM 4.—When P happens much oftener than Q, we feel a very high degree of probability (moral certainty) that the same thing would happen in the long run, or would continue how long soever we might go on trying, unless there should arrive some change of circumstances. But when P does not happen much oftener than Q, we do not feel the same degree of assurance; for though Q might really happen oftener than P in the long run, yet the casual fluctuations of events might make the contrary appear in any one set of trials. Suppose then that in $a+b$ trials, P has happened a times, and Q has happened b times, a and b being nearly equal: what presumption can thence be derived that the excess will be on the same side in the long run on which it is in the $a+b$ trials?

RULE.—Divide the difference of a and b by the square root of twice their sum: let the result be A, and find the corresponding B; to this add 1, and divide by 2: the result is the probability required.

EXAMPLE.—Buffon, in a particular experiment, had to throw a coin (say a halfpenny) 4140 times; the result was 2048 heads and 2092 tails: what is the probability that some excess of tail over head would have continued for ever; that is, that the coin he used had in its construction some mechanical tendency to fall tail rather than head? Here $a=2048$, $b=2092$; the difference divided by the square root of twice the sum is ·48, which being A, B is ·50, and 1·50 divided by 2 is ·75, the probability required. This is ¾, so that it is 3 to 1 that some excess or other of tails would be found in the long run. Observe however that this does not mean an excess to the amount of 44 in every 4140 trials; but only *some* excess, small or great: observe also that the character of the mint and its processes are supposed wholly unknown, so that no conclusion can be formed about the character of the coin except from the observed event.

The experiment of Buffon, and its particular object, will be found in the 'Essay on Probabilities and Life Contingencies,' in the 'Cabinet Cyclopædia;' in which work will also be found a larger collection of such problems as the preceding, with fuller explanation and more extensive tables. These problems have been here introduced that the reader may have an opportunity of comparing and verifying the general sameness of results which follows from the two (perhaps) apparently differing notions from which the idea of the measure of probability may be derived.

Previously to laying down a few general rules, we shall notice the error to which persons who have not thought on the subject are most liable: this is a confusion between the sort of confidence which is to be given to a result of the theory of probabilities, and that which is claimed by actual demonstration. Many persons are not aware that out of mathematics the greater number of conclusions are *probable* results: many of them, it is true, so highly probable that their chance of falsehood does not amount to that of drawing a black ball from among a million of white ones; but still not absolutely demonstrated. These highly probable results (so probable that the word probable in its common sense is weak as applied to them) form the ordinary knowledge of common life, and being practical certainties, are considered and mentioned as certainties, the imperceptibly small chance that they may not be true being disregarded. Hence it happens that when a result of this theory is announced, with its proper chance annexed, and though the probability of its truth is so high that it may rank with the moral certainties of ordinary life, there is a morbid disposition to dwell rather upon the one way in which the proposition may fail, than upon the million of equally possible ways in which it may be true. Thus if it be said that it is ten millions to one that P will happen, and not Q, therefore it is morally certain that P will happen—it is objected, But how do we know that the very next event will not be precisely the one of ten millions which is Q and not P? The answer is, we do not *know* it in the absolute sense of the word; if we thus knew it, it would be a certainty that P would happen, and whether P would happen or not would not be a question for the theory of probabilities at all: but we do know it in the common sense of the word, since there are hundreds of conclusions which all men call knowledge, which are not so probable that they can be reasonably shown to have ten millions to one in their favour.

Another way in which the confusion we have mentioned shows itself is, in the habit of reasoning against the probable truths just alluded to, by arguments which could only be valid against an assertion that these truths were absolutely demonstrated. In compliance with the forms of language, those who advance such truths treat them as (moral) certainties: the opponent overthrows their (mathematical) certainty, and the fallacy lies in his supposing that he has thereby shown them not to possess that sort of truth which was claimed for them. For example, a medical man gives his opinion that a crime committed without any apparent motive is an indication of insanity: a newspaper ridicules this opinion, and asks, Are there no motives then which cannot be discovered? Now, if by *apparent* was meant apparent on the surface, or with slight examination, and if by *indication* was meant an absolute indication, certainly inexplicable except by the supposition of insanity, the answer is complete, and the opinion shown to be untenable. But suppose the energies of many acute persons and the resources of a whole nation to fail in making the motive of a crime apparent, and that this is what is meant by there being no apparent motive; suppose moreover that by an indication of insanity is meant a circumstance which renders insanity so moderately probable that the hypothesis deserves to be weighed: the answer then is wholly irrelevant. The opinion, expanded into an argument, is—a crime committed absolutely without motive or object shows insanity; a motive, if it exist, may almost certainly be discovered by proper exertions; consequently the appearance of no motive, after all exertions to discover one have been tried, makes it most likely [*] that the crime was an act of insanity; it is in fact as likely that the crime was an act of insanity, as it was unlikely that the exertions to discover a motive should have failed, if there had been a motive.

The application of this theory to pure logic is contained in the consideration of testimony, argument, and their combination. The following rules [†] will be found demonstrated in De Morgan's 'Formal Logic,' ch. x.

Testimony, or authority—which means only testimony of great force, as the word is commonly used—speaks to the truth or falsehood of the assertion. But argument speaks, not to the truth or falsehood of the conclusion, but to the validity of the mode of establishing it. An argument may be invalid, either by false premises or bad logic: and yet the conclusion may be true. Consequently, the probability of an argument being valid is a totally different thing from that of the conclusion being true.

The effect of testimony, as also of argument, must depend upon the initial state of the receiver's mind with reference to the conclusion asserted. But though the receiver himself may stand in a very different position from the witnesses who bring him testimony, yet in the mathematical formulæ he ranks but as one of those witnesses: if his initial state be that it is 999 to 1 against the conclusion, the results of the theory are the same as if he, being unbiassed, found an additional witness to deny the assertion for whose correctness it is in his mind, *à priori*, 999 to 1. A person without any bias on his mind begins with an even chance for the assertion. And a witness of credibility μ, who asserts, ranks as a witness of credibility $1-\mu$, who denies. The following rules are given in mathematical form, for consistency with the rest of the article: the non-mathematical reader will find them reduced to arithmetical rules in De Morgan's 'Syllabus of a Proposed System of Logic,' 1860.

Let a number of witnesses, of credibilities μ, μ', &c., affirm: let others, of credibilities $\nu, \nu', \ldots,$ deny. By the credibility of a witness we mean the belief we have of an assertion of his being correct, before we turn our attention to the particular character of that assertion. Then the odds in favour of the assertion are $\mu \times \mu' \times \ldots\ldots \times (1-\nu) \times (1-\nu') \ldots\ldots$ to $(1-\mu) \times (1-\mu') \times \ldots\ldots \times \nu \times \nu' \ldots\ldots$ Let the probability of the assertion thence obtained (the first of the two divided by their sum) be called M: and remember that the receiver himself is one of those witnesses, as before explained.

Let a number of arguments of which the several probabilities of validity (that is, of their proving their conclusions true) be $a, a', \ldots\ldots$ The probability that the conclusion is proved—that is, that one or more are valid—is $1-(1-a)(1-a')\ldots\ldots$ If arguments be produced for the contradictory conclusion, of validities b, b', &c., then $1-(1-b)(1-b')\ldots\ldots$ is the probability that the conclusion is disproved. We speak of separate cases: the combination of arguments for and against will be instantly seen. Let these results be A and B. We may treat the conclusion, as now asserted to an unbiassed mind by a single witness of credibility M, supported by one argument of validity A, and opposed by one argument of validity B. The only difference is that if there be a plurality of witnesses or of arguments, we have to calculate M, A, B; which, when there is one only of each kind, are supposed given.

When testimony and argument are combined, the odds in favour of the conclusion are $M(1-B)$ to $(1-M)(1-A)$. The following cases may be distinguished:—

1. No evidence; arguments on both sides. Here $M=\frac{1}{2}$, and the *odds* [‡] are $1-B$ to $1-A$. When A and B are very near to unity, or

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[*] When this paragraph was written, there was a run against the hypothesis of insanity in criminal cases: since that time there has been a longer and stronger run in favour of it. Had this article been now first written, in all probability the illustration would have been drawn from the excess opposite to that chosen for comment in the text.

[†] The account of this matter given in the 'Penny Cyclopædia' is not correct, though something nearer the mark than anything which preceded. The logicians had constantly confounded the probability of validity of an argument with the probability of truth of its conclusion; and the article just referred to followed them in their principle, though not in their details.

[‡] This word is connected with gambling associations; and so is the word *chance*. We substitute *probability* for the second word, which is used ambiguously [CHANCE]: but we cannot conveniently dispense with *odds*; the following anecdote, however, may go some way to purify the polluted word. It is told by the distinguished experimenter, Professor Faraday, in a lecture 'On Mental Training' (12mo, 1854). "When I was young, I received from one well able to aid a learner in his endeavours towards self-improvement, a curious lesson in the mode of estimating the amount of belief one might be induced to

both arguments very powerful, it is to be assumed that the mind does not see the ratio of the small quantities, and the question is evenly balanced.

2. No evidence; only argument for. The odds are 1 to 1—A; taken by all the logicians who have considered the subject to be A to 1—A. The first result is always greater than the second; which means that even if the argument be invalid, the conclusion may still be true, and has some probability left.

3. A witness of given credibility does not add so much to the force of the conclusion as an argument of the same probability of validity. We introduce this assertion as one of common sense: if the witness be wrong the assertion is false: if the argument be invalid, the assertion may still be true; consequently the argument is better than the witness. How do the formulæ verify this? As follows:—if a be the probability of both, the odds for the truth are altered by the witness in the proportion of a to $1-a$ and, by the argument in the greater proportion of 1 to $1-a$.

4. Any argument, however slight its force, adds something to the force of its conclusion: for alteration in the ratio of 1 to $1-a$ is increase, let a be ever so small. But it must be remembered that this is only true of the argument *per se*, and has no reference to the possibility of the weakness of the argument being itself an argument on the other side. If a weak argument be brought forward by a person who most probably would know the stronger ones, if there were any, the argument on the other side just spoken of may arise. On this, however, and other points, our space obliges us to content ourselves with the reference already made.

The various problems of which the solutions have been given are mathematical consequences of the definition of probability. Every such problem is simply one of combinations, however much the length of detail, and the number of mathematical abbreviations of the process of combining, may tend to make us lose sight of the first principle. At the same time it is found requisite to establish a few simple fundamental propositions, which we shall cite, with some consequences. As we are not writing an elementary treatise, we shall not demonstrate these propositions, referring the student to any of the modern works hereinafter cited. The probabilities of the events A, B, C, &c., are denoted by a, b, c, &c.

1. By a, the probability of A, is meant the fraction which the number of cases favourable to the happening of A is of the whole number of cases, that is, both of those in which A can happen, and those in which it cannot: all cases being equally likely. And the probability that A will not happen is $1-a$.

2. When A and B are events independent of each other, so that the happening of either in no way promotes nor retards the happening of the other, the probability that both shall happen is ab; that neither shall happen, $1-a-b+ab$; that one only shall happen, $a+b-2ab$; that one or both shall happen, $a+b-ab$.

3. When A and B are mutually exclusive, that is, when if one happen the other cannot, the probability that one or other shall happen is $a+b$; and that neither shall happen, $1-a-b$.

4. If either A or B must happen, $a+b=1$; and if n trials are to be made, the several terms in the expansion of $(a+b)^n$ are the chances of the arrivals denoted by their exponents. Thus—

a^n is the chance that all are As.

$n a^{n-1}b$, that $n-1$ are As and one is B.

$n\dfrac{n-1}{2}a^{n-2}b$, that $n-2$ are As and two are Bs, &c.

5. When an event has happened which may have sprung from any one of the sets of circumstances which we may describe by A, B, C, D, &c., and it is desired to find what is the probability of the event which did happen having arisen from one or another set, proceed as follows:—Had the circumstances denoted by A certainly existed, and the event been a contingency, let a be the probability that those circumstances would have produced the event; or briefly, let a be the probability that A, when certain, brings about the event. Let b be the same for B certain, c for C, &c. Then the probability that it was A which brought about the event which did happen, is the first of the following set:—

$$\frac{a}{a+b+c+\&c.},\quad \frac{b}{a+b+c+\&c.},\quad \frac{c}{a+b+c+\&c.},\ \&c.$$

the probability that it was B is the second, that it was C the third, and so on. Or, when convenient, instead of a, b, c, &c., may be substituted any whole numbers which are proportional to them. For example, let there be three lotteries, containing balls as follows:—

all white,	4 white, 1 black,	2 white, 7 black.

A drawing has been made three times from one of these, but from which is not known, the ball being replaced after the drawing, and every drawing has given a white ball. Required the chances in favour of each of these lotteries having been the one drawn from. If it had been the first, the chance of the event would have been 1 (or certainty); if it had been the second, the chance of the event would have been $\frac{4}{5}\times\frac{4}{5}\times\frac{4}{5}$, or, $\frac{64}{125}$; if it had been the third, the chance would have been $\frac{2}{9}\times\frac{2}{9}\times\frac{2}{9}$, or, $\frac{8}{729}$. The numerators of these fractions, reduced to a common denominator, are 91125, 46656, and 1000; whence the probability that the lottery drawn from was the first, is

$$\frac{91125}{91125+46656+1000},\text{ or }\frac{91125}{138781};$$

and the probabilities of the second and third lotteries are

$$\frac{46656}{138781}\text{ and }\frac{1000}{138781}.$$

The preceding question is well calculated to show the meaning of questions in this theory, which is thus seen to be applied to events, not because they are *uncertain*, but because they are *unknown*. So soon as the lottery is chosen, it is certain which it is, but since it is not known to the drawer, it is to him as much a contingency as it was before it was chosen.

6. When, in such a case as the preceding, it is required to know the probabilities of the events which may happen at any further trials, the probability of each lottery having been the one in question is to be multiplied by the probability of the new event arising from that lottery taken as certain, and the results added together. Thus, suppose there are two lotteries, one having all white balls, and the other equal numbers of white and black balls; two drawings have been made from one of them (not known) and both drawings have given a white ball; what is the probability that a third drawing from the same lottery would also give a white ball? The chances for the two lotteries are found by the last to be $\frac{4}{5}$ and $\frac{1}{5}$, while the chances of a white ball from one and the other are 1 and $\frac{1}{2}$. It follows that $\frac{4}{5}\times 1+\frac{1}{5}\times\frac{1}{2}$, or $\frac{9}{10}$, is the chance of the third drawing giving a white ball.

7. If A or B must happen at every trial, and if in m trials nothing but A has happened, and if we know nothing whatever about the nature of preceding circumstances, then it is $m+1$ to 1 that A shall happen at the next trial, and $m+1$ to k that A shall happen throughout the next k trials. But if in $m+n$ trials A have occurred m times and B n times, it is $m+1$ to $n+1$ that A shall occur at the next trial.

8. Every event that *can* happen *must* happen, if trials enough be made; and not only must happen, but must happen any number of times in succession. For example, if there be only one white ball to 100 black ones in an urn, and if drawings enough be made, the ball drawn being always returned and the urn properly shaken before a new trial, a person who goes on must at last draw that single white ball 1000 times running. This is a conclusion which the beginner cannot receive, particularly when he is told that 1,000,000 might be written for 1000, or any other number however high. Nevertheless, it will, in the course of his studies, not only be made clear to him, but it will also be shown that it is a conclusion which may be made obvious to common sense without any very profound mathematics.

9. If the odds against an event happening at any one trial be n to 1, there is an even chance of its happening in ·69 × n trials,* it is 10 to 1 that it happens in 2·40 × n trials, 100 to 1 that it happens in 4·62 × n trials, 1000 to 1 that it happens in 6·91 × n trials, and 10,000 to 1 that it happens in 9·21 × n trials. Thus if it be 200 to 1 against success in any one trial, 9·21 × 200 being 1842, it is 10,000 to 1 that there shall be one success at least in about 1842 trials. But if a person should make 1000 trials without one success, he would have no right to say that it is 10,000 to 1 in favour of one or more successes in the next 842 trials.

10. When any sum depends upon a contingent event, the present value of that sum is such a fraction of it as the probability of the event happening is of unity. Thus 20*l.* to be gained if an event happen against which it is 7 to 1, is now worth only the eighth part of 20*l.*

There are no questions in the whole range of applied mathematics which require such close attention, and in which it is so difficult to escape error, as those which occur in the theory of probabilities. This makes it hard to lay down in a short space either maxims or examples sufficient to be really of use in advancing the student's progress: and

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attach to our conclusions. That person was Dr. Wollaston, who, upon a given point, was induced to offer me a wager of two to one on the affirmative. I rather impertinently quoted Butler's well-known lines—

> 'Quoth she, I've heard old cunning stagers
> Say fools for arguments use wagers,'

about the kind of persons who use wagers for argument, and he gently explained to me that he considered such a wager not as a thoughtless thing, but as the expression of the amount of belief in the mind of the person offering it; combining this curious application of the wager, as a *meter*, with the necessity that ever existed of drawing conclusions, not absolute, but proportionate to the evidence."

* The numbers ·69, 2·40, &c., are all approximations.

of all subjects, there is no one in which writers of every grade have so frequently or so strangely made mistakes of mere inadvertence. One was pointed out about twenty years ago ('Camb. Phil. Trans.') into which both Laplace and Poisson had fallen, one after the other; but the discoverer of their slip proved himself signally liable to greater ones a very little while after. ('Cab. Cyclop.: Probability and Life Insurance,' p. 28.)

We shall conclude by a brief account of the historical progress of this branch of science; referring the reader for more detail to Montucla, and to the Treatise 'On Probability,' in the 'Library of Useful Knowledge.' Those who cultivated games of chance must at all times have had a general notion of combinations which were more probable than others, and must have seen that those cases of which there were most to happen, always did in reality happen most often. They could not fail to know, by reckoning on their fingers, that out of, for instance, all the throws of a pair of dice, there are only six doublets, and thirty other equally possible cases; nor could they have missed knowing that this must be the reason why doublets occur seldom in comparison with other throws. Notwithstanding this, the mathematical history of the subject usually dates from a fragment by Galileo, which merely shows why 10 can be oftener thrown on three dice than 9, and two problems proposed by Chevalier de Méré to Pascal, in 1654, concerning certain points connected with games of chance.

That the history of *correct* investigation dates from this period there can be little doubt, but the subject had been previously considered by Cardan, in a work, 'De Ludo Aleæ,' published from his manuscript in the first volume of the collected edition of his works, and never separately; and also so badly printed as to be almost unintelligible; circumstances both of which have probably contributed to keep it, as it has been kept, totally out of view. Cardan's theory is perfectly false: he supposes, for example, that since there are six faces to a die, it will happen in the long run that each face will come up once in six throws, which is true when many collections of six throws are averaged; but from this he draws the false conclusion that it is an even chance that any one face comes up in three throws. His numerical reasoning is therefore totally incorrect; but his notions on the general subject of probability are reasonably sound. Fortune, according to him, does not decide the general average of the play, but only the deviations on one side and the other which a small number of cases present; and experiment would, he says, prove that the long run would agree with the predictions of theory; it were to be wished that he had tried it on his own theory. This treatise was written about 1564, and published in 1663. But before this, in 1657, the tract of Huyghens, 'De Ratiociniis in Ludo Aleæ,' was published as an appendix to Schooten's 'Exercitationes Geometricæ,' being not only the first regular treatise, but the first which applies the theory to chances of loss or gain. It was translated into English, with additions, in 1692, the reputed translator being Motte, the secretary of the Royal Society. Then followed the 'Analyse des Jeux de Hasard,' by Montmort (first edition 1708, second, enlarged, 1713), a work of higher mathematical pretensions. The 'Ars Conjectandi,' of James Bernoulli, posthumously published by his nephew Nicolas, in 1713 (and which, it may be worth noting, is not contained in the collection of James Bernoulli's works), gives the first glimpse of the more difficult class of problems in which processes containing very large numbers are abbreviated by mathematical analysis. This was carried still further by De Moivre, whose first work, a paper, 'De Mensura Sortis' ('Phil. Trans.,' 1711), was expanded into his celebrated treatise on the doctrine of chances, first edition 1718 (not 1716, as frequently stated), second edition 1738, third edition, with his 'Treatise on Life Annuities,' 1756. The next step was made by Bayes ('Phil. Trans.,' 1763 and 1764), who first considered the probability of hypotheses as deduced from observed events.

The great work of Laplace (first edition 1812, third 1820) had in great part appeared at various previous times in the 'Memoirs' of the Academy of Sciences. It is remarkable, first by the extension of methods which it furnishes; secondly, by its giving at one view the whole state of the science and its applications; thirdly, by the particular attention given to the application of the theory to the results of observation. [Mean; Least Squares.] The next step in the history is Poisson's 'Recherches sur les Probabilités des Jugemens,' 1837, which gives the grand results of Laplace by a somewhat different analysis, and applies them particularly to the decisions of courts of law. This species of application had been before considered by Condorcet, in his 'Essai sur l'Application de l'Analyse à la Probabilité des Decisions,' Paris, 1785. It may also be worth while to mention the 'Traité de Calcul Conjectural,' of Parisot, Paris, 1810, a work which deals largely in the theory of simple combinations. The elementary work of longest standing, which exhibits some view of the higher mathematical applications, is the 'Traité Elémentaire du Calcul des Probabilités,' by M. Lacroix (second edition, 1822). The 'Essai Philosophique' of Laplace, which is an introduction to the third edition of his theory, contains no mathematics, and may be usefully read with any elementary treatise. The 'Instructions Populaires sur le Calcul des Probabilités' by M. Quetelet, Brussels, 1828, contains the most elementary view of the subject, and uses only simple arithmetic.

In England, since the publication of Simpson's 'Laws of Chance,' 1740, and the 'Laws of Chance,' by Samuel Clark, 1758, little was written on the mathematical theory except so far as it had reference to life annuities and assurance, until a very recent period. About 1830 Messrs. Lubbock and Drinkwater (Bethune) published a tract 'On Probability,' in the 'Library of Useful Knowledge,' giving more general methods of applying modern algebraical investigation than had before appeared in this country: by a binder's mistake this work is often attributed to Mr. De Morgan. In 1837, the article 'Theory of Probabilities,' in the 'Encyclopædia Metropolitana,' written by Mr. De Morgan, gave the results and methods of Laplace on most of the great questions of the theory. The 'Essay on Probabilities, and on their Application to Life Contingencies and Insurance Offices,' published by the same writer in the 'Cabinet Cyclopædia,' 1838, exhibits the principles without mathematical investigation, and the results arranged in rules for use. The article on 'Probability' in the new edition of the 'Encyclopædia Metropolitana,' by Mr. Galloway, gives the mathematical investigation of the higher parts of the theory, following the methods of Poisson. This treatise is published separately.

On subjects connected with this article, see Gaming; Risk; Wager; Mean; Least Squares; Observation and Experiment; Weight of Observations; Annuity; Mortality; Reversion, &c.

PROBATE. [Will.]

PROBATE, COURT OF. The grant of letters of administration of the effects of persons dying intestate, and of probate of the wills of testators, which were formerly the prerogative of the Ecclesiastical Courts [Ecclesiastical Courts], have been recently (20 & 21 Vict. c. 77) vested in a newly established court, called the Court of Probate. The functions of this court are confined entirely to deciding upon the authenticity of wills, and upon the proper persons to whom administration is to be committed, when no will exists. With the distribution of the property of deceased persons, and the rights of the various parties who claim it beneficially, the court has nothing to do. These matters must be decided by the courts of law and equity, as before the passing of the Act. The duties of executors and administrators remain the same as formerly. A central registry of wills and administration is established in London, and district registrars are established in forty of the principal towns of England. The office or registry in which probate or a grant of administration is to be sought, is no longer to be determined by the locality of the *assets* of the deceased person, but by the place where the deceased had a fixed abode at the time of death. Should the testator or intestate have a permanent place of residence in one of the registry districts at the time of his decease, probate or grant of administration may be obtained there; but the executors or parties claiming administration may, if they think fit, apply to the principal or metropolitan registry, and this may in some cases be found more convenient. Original wills proved in the country will be preserved in the district registries; but copies of them will be transmitted to the principal registry in London, so that in future the metropolitan registry will be the most convenient office of search for any will whatsoever.

The practice of the Court of Probate has been thrown open to the whole legal profession, so that the close monopoly of testamentary business formerly enjoyed by advocates and proctors is at an end. The court is presided over by a single judge, who sits at Westminster. An appeal lies from his decision direct to the House of Lords.

In cases where a person dies in one of the forty districts, leaving personal property under 200*l.*, the judge of the County Court of the district has jurisdiction should any contention arise, but from his decision an appeal, which is final, lies to the Court of Probate.

One principal advantage of the new system lies in the removal of all difficulty as to the question where a will ought to be proved, and the old question of *bona notabilia*, on which the necessity of obtaining prerogative probate or administration was founded. The rules of evidence in the Court of Probate are to be the same as those in courts of law and equity, while its proceedings are likewise assimilated to those of the courts of common law.

The duties raised in the Probate Court yielded in the year ending March 31, 1860, the sum of 3,463,226*l.*, including the succession duties. The legacy duty is charged on legacies of the value of 20*l.* and upwards out of personal estate or charged upon real estate, and upon every share of residue. Legacy to a husband or wife is exempt from duty. To a child, the husband of a child, a parent, or any lineal descendant or ancestor of the deceased, the duty is 1*l.* per. cent.; to a brother or sister or their descendants, 3*l.* per cent.; to an uncle or aunt or their descendants, 5*l.* per cent.; to a great uncle or great aunt or their descendants, 6*l.* per cent.; to any other relation or any stranger in blood, 10*l.* per cent. The probate duty is payable on the total sum left by the deceased. For sums above 20*l.* and not exceeding 100*l.* the duty is 10*s.* if there is a will; and if there is no will the duty of 10*s.* is chargeable on sums of 20*l.* and not exceeding 50*l.* The duties continue to increase according to a certain scale. The succession duties on real estate have the same scale, and the valuation is made according to the worth as an annuity.

PROBLEM (*πρόβλημα*) means simply a thing put forward or proposed. In mathematical language it is anything which is required to be done, and in the earlier writers is distinguished from a theorem, or assertion to be proved, in that the latter does not require any specific object to be effected. Thus, "all the angles of a triangle are together equal to two right angles" is to be shown or made evident, and is a theorem; but "to draw a circle through three given points" presents an object to be effected, and is a problem. But it must be remembered that this difference lies more in the nature of the result than in the method; for the solution of this problem, so called, is an intuitive corollary from the theorem that if three points be joined, and perpendiculars be drawn bisecting two of the joining lines, the intersection of these perpendiculars is equidistant from the three points. It is also to be noted that this distinction of theorem and problem appears neither in the Greek of Euclid, Apollonius, nor Archimedes, the general term employed by all three, and in all cases, being πρότασις, which is translated by proposition. The distinction then is of a later date, and is the work of annotators; it appears in Pappus, according to the Latin of Commandine. It does not appear in the translation of Euclid by Athelard (which goes by the name of Campanus); and the first edition of the Elements in which we find it is the subsequent edition of Zambertus. If we leave the modern followers of the old geometers, we find the word problem used in its simple etymological sense of something proposed; but for the most part employed when the something proposed contains, or has contained, a remarkable difficulty. Thus to this day we talk of the problem of three bodies, as being one of the methods which are hoped to be found capable of decided improvement. In algebra the word is variously used, though, according to the ancient distinction, the solution of any equation of condition should be called a problem, and the establishment of any identity a theorem.

PROCESS. This term, in its original sense, comprehends the whole of the proceedings which take place, and are recorded by the court, in the course of a suit, criminal or civil, previous to final judgment. In this sense the word (*processus, procès*) is used in the French and Scotch laws. In its more ordinary and limited signification, the term is applied to the writs which issue out of any court for the purpose of compelling the parties to a suit, and other persons whose co-operation is required, to do some act connected with the progress of the suit. In this sense, also, process is either civil or criminal

Civil process was formerly, and until lately, practically divided into original, mesne (intermediate), and final process.

Original process, more commonly known as original writs, issued out of the common-law side or department of the Court of Chancery. Since the substitution for it of *writs of summons*, the latter are sometimes, though erroneously, called original process.

Mesne process is that which issues between the first writ and final judgment, including writs issued for the purpose of compelling the attendance of jurors and of witnesses, and for other collateral purposes. To avoid the expense and delay of an original writ, it was usual to commence actions by mesne process, founded upon a supposed original writ which never had in fact issued; and, by degrees, all process before final judgment, except the original writ, acquired the name of mesne process, even in cases where it formed the legal as well as the actual commencement of the suit, as in *scire facias, auditâ querelâ*, &c.

Final process is the term applied to express writs of execution. [EXECUTION.]

Mesne and final process are sometimes called judicial process, because they issue under the authority of the court in which the action is pending. A great variety existed in the different forms of process by which actions were formerly commenced in the three superior common-law courts; but in all actions the process is now a *writ of summons*, in a form prescribed by statute, which is addressed to the defendant, and requires him to cause an appearance to be entered within eight days from the service of the writ. If the writ be served on the defendant, or so served that it must have come to his knowledge, and he does not enter an appearance, the plaintiff may sign judgment by default.

Arrest upon *mesne* process (as it is called in the statute) was taken away by 1 & 2 Vict. c. 110, except in cases where an arrest is ordered by the court or a judge; in which case a *capias* may issue at the same time as the writ of summons.

(See 3 & 4 Will. IV. c. 27, s. 36; 2 & 3 Vict. c. 27, s. 3; the Common Law Procedure Acts of 1852, 1854, and 1860; the Bills of Exchange Act, 1855; and the Bankrupt Law Consolidation Act.)

Criminal Process.—Where an indictment [INDICTMENT] for treason or felony is found by a grand jury, process of *capias* issues to the sheriff, commanding him to arrest the indictee. But where an indictment found, or an information filed, charges the party with a misdemeanor only, the process is at common law a *venire facias*, being a command to the sheriff to cause the indictee, &c., to come into court, which, under this process, must be done by summoning him. If the indictee, &c., do not obey the summons, and it appears by the return that the indictee, &c., has lands in the county, a writ of *distringas* issues, commanding the sheriff to compel the indictee to appear, by distraining him by the issues (the produce) of those lands, to appear. If the return to the *venire facias* shows that the indictee has no lands, process of *capias* issues.

Before any indictment is found, a party charged upon oath with treason or felony may be brought before a magistrate by virtue of a warrant issued for his apprehension by the same or some other magistrate of the district, and may by another warrant be committed to prison for trial, if upon the examination there appear to be grounds to suspect that the party is guilty. (11 & 12 Vict. c. 42.)

A bench warrant, as it is termed, may also be issued by the justices of assize when an indictment is found.

PROCESS-VERBAL (*Procès-verbal*) is a term derived from French jurisprudence, in which it signifies a memorandum or instrument drawn up and attested by officers of justice, containing a statement of the circumstances which have taken place upon the execution of a commission, upon an arrest, upon a precognition or preliminary examination of a party accused, or in the course of other legal investigations, and set forth in the order in which they have occurred. The term is now frequently applied to a contemporaneous detailed minute or note of any formal proceeding, though not occurring in the course of any legal inquiry: *ex. gra.*, a note of the discussions which are taking place during the negotiation of a treaty, &c.

PROCLAMATION. By the constitution of England, the crown possesses the exclusive prerogative of issuing proclamations; for although this authority is exercised by the lord mayor in the city of London, and by the heads of some other corporations in other cities, for certain limited purposes, it is always founded upon custom or charter, and consequently only exists in such cases by delegation from the crown.

The nature and objects of royal proclamations are various. In some instances they are merely an authoritative promulgation of matters of state, or of acts of the executive government which it is necessary that all persons should know, and upon notice of which, as presumed to be conveyed by a public proclamation, certain duties and obligations attach to subjects. Proclamations of the accession of a new king or a demise of the crown, and proclamations for reprisals upon a declaration of war with a foreign state, and for rendering coin current within the realm, are examples of this kind. Another class of proclamations consists of those which declare the intention of the crown to exercise some prerogative or enforce the execution of some law which may have been for a time dormant or suspended, but which a change of circumstances renders it necessary to call into operation. Thus the crown might, by a proclamation in time of war, lay an embargo upon shipping, and order the ports to be shut, by virtue of its ancient and undoubted prerogative of prohibiting any of its subjects from leaving the realm. Another, and by far the most usual, class of proclamations issued by the crown consists of formal declarations of existing laws and penalties, and of the intentions of government to enforce them, designed, as some of the early books term it, *quoad terrorem populi*, and merely as admonitory notices for the prevention of offences. A familiar instance of this kind of declaration is the proclamation against vice and immorality, appointed to be read at the opening of all courts of quarter-sessions.

At present the royal prerogative does not authorise the creation of an offence by proclamation which is not a crime by the law of the land. In early periods of our history after the Norman conquest, the power of the crown in this respect appears to have been much more extensive, and instances of proclamations may be found in Rymer's 'Fœdera,' and elsewhere, evincing an assumption of almost despotic authority by the crown. In the reign of Henry VIII. the king was enabled, with the advice of his council, to set forth proclamations under such penalties and pains as to him might seem necessary; but this was by Act of Parliament, and the statute was repealed about five years afterwards. A strenuous attempt was made in the reign of James I. to strengthen the crown by increasing the prerogative of making proclamations, which, though encouraged and promoted by the Lord Chancellor Ellesmere and Bacon, were resisted by Coke, and occasioned great alarm and dissatisfaction among the people. The encroachments which had been made and attempted in this respect are enumerated and complained of in the 'Petition of Grievances' by the Commons, in 1610 (Howell's 'State Trials,' vol. ii.); and in the same year it was expressly resolved by the judges (of whom Sir Edward Coke was one) that the king could not by his proclamation create an offence which was not an offence before; "for if so, he might alter the law of the land by his proclamation." (Coke's 'Reports,' part 12.)

PROCONSUL. [CONSUL; PROVINCIA.]

PROCTOR, derived from the civil law term "procurator"—one that seeth after another man's affairs. It is the designation of those who in the Ecclesiastical and Admiralty courts (where the forms of the civil law prevail), conduct the business of their clients as attorneys and solicitors do in the courts of law and equity, but in order to enable them to act in the Ecclesiastical court, they must be formally authorised by a "proxy" from their clients to do so (129 a. Canon). Proctors also act as notaries public, in attesting acts and conducting proceedings in their own courts, but they do not possess the authority of notaries generally. In order to practise in the Ecclesiastical courts, they must be admitted by the archbishops of the respective provinces, by application to their vicar-general or official principal. In the Admiralty court they are admitted by the judge of the court.

The recent Acts of Parliament, however, the 20 & 21 Vict. c. 77 (the Act to amend the law relating to Probates and Letters of Administration), and the 20 & 21 Vict. c. 85 (the Act to amend the law relating to Divorce and Matrimonial Causes), have transferred to the temporal courts the jurisdiction of the Ecclesiastical courts over wills, intestacies, and divorce, and in so doing, the practice is no longer confined to proctors, but is thrown open to barristers, attorneys, and solicitors. The 22 & 23 Vict. c. 6, also empowers barristers, attorneys, and solicitors, to practise in the court of Admiralty. Thus the practice in the testamentary and matrimonial business of the Ecclesiastical courts and that of the court of Admiralty is no longer confined to the advocates and proctors of Doctors' Commons. Marriage licences are obtained through the medium of proctors: they prepare the affidavit containing the particulars required to enable parties to be married without the publication of banns. The 5 Geo. II. c. 18, s. 2, prohibits practising proctors from being justices of the peace. But they are exempt from serving on juries, or being made parish officers, as churchwardens, &c. The term "proctor" is also applied to those of the clergy, who are selected by their brother clergy to represent them in convocation [CONVOCATION]. For the practice of the Ecclesiastical courts, see COURTS, ECCLESIASTICAL.

The two proctors in the universities of Oxford and Cambridge are nominated by each college in rotation from among the resident masters of arts. They hold office for a year; they each have two proproctors. Their office is of great dignity and importance; they rank after the vice-chancellor. Their duties are to preserve order and discipline among the under-graduates, and to aid the authorities in all their important functions.

PROCURATOR, a manager or agent, whence the word proctor is formed.

A Roman procurator was a person appointed by another to conduct a cause for him, and it required no particular words to constitute a procurator. A man might commence a suit as a procurator, without showing his authority; but he was obliged to produce it before the judges came to a decision, or to enter into security that the plaintiff would abide by his acts. (Gaius, iv. 84.)

Under the Empire the governor of a province was, in certain cases, called a Procurator, or Procurator Cæsaris. Sometimes this Procurator had not the government of a province, but only managed affairs of revenue (res fisci). [PROVINCIA.]

Solicitors in Scotland who practise in the courts of the Sheriffs, are usually called Procurators; and in judgments the courts generally recite the hearing of the Procurators of the parties.

Procurator Fiscal, in Scotland, is the term used to denote the public prosecutor.

PROCYON. [SIRIUS and PROCYON.]

PRODUCT, a term really equivalent to result, but used only when the result is the one obtained by the multiplication of two or more quantities.

PROFANENESS. [BLASPHEMY.]

PROFIT, one of the three parts into which all that is derived from the soil by labour and capital is distributed, the other two being wages and rent: from these three sources arise all the revenues of the community. Profit is therefore the surplus which remains to the capitalist after he has been reimbursed for the wages advanced and the capital expended during the process of production. To obtain this surplus is the only object for which capital is employed.

Profits have a tendency to fall to the same level in all branches of industry; for if the ratio of profit in proportion to the capital employed be greater in one than in another, more capital will be directed to that which affords the highest profit; and the powers of production being increased, the supply is greater, prices fall, and the equilibrium of profit is restored. A distinction must however be made between real and apparent profit. When the employment of capital is attended with extraordinary risk, profits are nominally high; but after deducting the losses to which it is exposed, the real profits tend to the same level as the ordinary rate. The case is similar in occupations of a disagreeable or agreeable nature, the pleasantness of the latter counterbalancing the low rate of profit. A wholesale merchant and a retail trader both dealing in the same commodities may appear to obtain different rates of profit; but in the latter case wages are confounded with profits, and when they are properly distinguished, the apparent disproportion is diminished. Unless we reduce profits from their apparent to their real value, there is no truth in the maxim that the rate of profit is uniform in the same country at the same time.

The natural tendency of profits (whether arising from capital employed in agriculture or in manufactures) is to decline as the necessities of the population render it necessary to have recourse to inferior soils. Happily, improvements in machinery and in the art of agriculture, better combinations of labour and capital, and greater freedom of commerce, are calculated to arrest this retrograde movement; and to such sources of relief every highly advanced country must look as a means of sustaining its prosperity; for whatever diminishes the necessity of raising food from the poorer soils, tends to maintain the rate of profit.

Two other causes have great influence upon the rate of profit, namely, wages and taxation. A rise in wages will diminish profits, unless industry becomes more productive; but if the latter take place, both may rise at the same time, either in the same or in different proportions according to circumstances.

Taxation will diminish profits, unless wages fall or industry become more productive. Taxes on profits, when they fall alike upon all capital engaged in productive industry, are paid by the owners of capital, who have not the power of charging the tax upon consumers. The means of accumulation are diminished when the profits of only certain classes of traders are taxed, and they would betake themselves to other occupations not taxed, unless they could charge the consumers with the tax: the tax therefore falls upon the consumers.

The competition of capitalists also acts in reducing the rate of profit, though this has been denied by some writers. Capitalists who have accumulated at the old rate of profit are content with a new investment producing a lower rate, instead of consuming their savings unproductively.

PROGNOSIS (in Medicine) is the opinion formed respecting the probable future events of any disease, as, for example, whether it will terminate in recovery or in death, how long it is likely to continue, what other diseases may be expected to arise in its course, what are the chances of relapse, and what those of some permanent injury of structure or function being produced by the morbid processes.

PROGRESSION. A series of numbers following any law should be called a progression, but the word is usually restricted to two sorts of progression, which are called, but by no means correctly, arithmetical and geometrical: the analogies pointed out in RECTANGLE give the origin of these terms.

An *arithmetical progression* is one in which the terms continually increase or diminish equally, including, as an extreme case, that in which they do not increase or diminish at all. Thus

$$\begin{array}{ll} 7,\ 7,\ 7,\ 7,\ \&c. & 7,\ 8,\ 9,\ 10,\ \&c. \\ 10,\ 9\tfrac{1}{2},\ 9,\ 8\tfrac{1}{2},\ \&c. & 2,\ 3\tfrac{1}{4},\ 4\tfrac{1}{2},\ 5\tfrac{3}{4},\ \&c. \end{array}$$

are sets of terms in arithmetical progression. The following proposition contains the principal part of their theory:—

If a be the first term of an arithmetical progression, and Δa the difference between any two terms (negative, if the terms diminish); and if a_n be the nth term from and after a *exclusive*, and s_n the sum of n terms, we have

$$a_n = a + n\,\Delta a\,;$$
$$s_n = na + n\,\frac{n-1}{2}\,\Delta a.$$

From these two equations between a, n, a_n, Δa, and s_n, any three of these being given, the other two can be found, subject however to this restriction, that the problem is unmeaning when n is not a whole number, whether it be given or found. These theorems are only the simplest case of a more general pair, in which, taking any series, and supposing neither the differences nor the differences of the differences, &c., to be equal, an expression is given for any term of a series, or for the sum of n terms, which frequently gives definite forms in the place of indefinite ones. Calculate, as in the article DIFFERENCE, the value of Δa, $\Delta^2 a$, &c., from a, a_1, a_2, &c., and let

$$n_1 = n,\ n_2 = n\,\frac{n-1}{2},\ n_3 = n\,\frac{n-1}{2}\,\frac{n-2}{3},\ \&c.$$

Then
$$a_n = a + n_1\,\Delta a + n_2\Delta^2 a + n_3\Delta^3 a +,\ \&c.$$
$$s_n = n_1 a + n_2\Delta a + n_3\Delta^2 a + n_4\Delta^3 a +,\ \&c.$$

Thus in the series 1 + 5 + 17 + 43 + 89 + 161 + &c., the law of whose terms is undiscoverable at first sight, we shall, by what the beginner may, till he knows better, call an accidental circumstance, discover both the law of the terms and that of their sum, as follows:—

$$\begin{array}{rrrrrr} 1 & & & & & \\ & 4 & & & & \\ 5 & & 8 & & & \\ & 12 & & 6 & & \\ 17 & & 14 & & 0 & \\ & 26 & & 6 & & 0 \\ 43 & & 20 & & 0 & \\ & 46 & & 6 & & \\ 89 & & 26 & & & \\ & 72 & & & & \\ 161 & & & & & \end{array}$$

$a=1$, $\Delta a=4$, $\Delta^2 a=8$, $\Delta^3 a=6$, $\Delta^4 a=0$, $\Delta^5 a=0$, &c.

$$a_n = 1 + 4n_1 + 8n_2 + 6n_3 = n^3 + (n+1)^2$$
$$s_n = n + 4n_2 + 8n_3 + 6n_4$$
$$= \left(n\,\frac{n-1}{2}\right)^2 + \frac{n(n+1)(2n+1)}{6}.$$

Thus the seventh term (the sixth after 1, $n=6$) is 6^3+7^2, or 265, and the sum of 6 terms (make $n=6$ in the second formula, in which remember that s^n is the sum of n terms, not of n terms after a) is $(\frac{1}{2}.6.5)^2+\frac{1}{6}.6.7.13$, or 316, which may easily be verified. [SUM.]

The apparently accidental circumstance above alluded to, is the vanishing of all the differences of a from and after the fourth. But it is to be observed, that the series was originally constructed so as to make all differences vanish after the fourth, and that the preceding theorem will never change indefinite into definite formulæ, except when all differences after a certain one vanish. The rule is, when a_n is an algebraically rational and integral function of n of the p order, that is, of the form $kn^p + ln^{p-1} +$, &c., all differences after the pth vanish, and then only.

Geometrical Progression is when the terms of a series increase or diminish by the use of the same multiplier, whole or fractional, including, as an extreme case, that in which the multiplier is unity.

Thus, the multipliers being 1, $\frac{8}{7}$, $\frac{1}{2}$, and 2, the four following sets of terms are in geometrical progression :—

$$7, 7, 7, 7, \&c. \qquad 7, 8, \tfrac{64}{7}, \tfrac{512}{49}, \&c.$$
$$3, \tfrac{3}{2}, \tfrac{3}{4}, \tfrac{3}{8}, \&c. \qquad 9, 18, 36, 72, \&c.$$

If a be the first term, and b the second, the nth term is $a\,(b \div a)^{n-1}$, and the sum of n terms is

$$\frac{a^n - b^n}{a^{n-2}(a-b)} \quad \text{or} \quad \frac{b^n - a^n}{a^{n-2}(b-a)}$$

according as a is greater than or less than b. But when $a = b$, the sum is of course na. If $b \div a = r$, that is, if the terms be a, ar^2, ar^3, &c., the nth term is ar^{n-1}, and the sum of n terms is

$$a\,\frac{1-r^n}{1-r} \quad \text{or} \quad a\,\frac{r^n-1}{r-1},$$

according as r is less than or greater than one. If r be less than one, the series of terms, however far it may be carried, never reaches $a \div (1-r)$, though it may approach this limit with any degree of nearness by making the number of terms sufficiently great.

Thus the following equations,

$$2 = 1 + \tfrac{1}{2} + \tfrac{1}{4} + \tfrac{1}{8} + \tfrac{1}{16} + \&c.$$
$$1 = \tfrac{2}{3} + \tfrac{2}{9} + \tfrac{2}{27} + \tfrac{2}{81} + \tfrac{2}{243} + \&c.$$

though always erroneous, stop where we may, yet can be brought as near to truth as we please by writing down terms enough on the second side. In the use of the word INFINITE, as explained in the article on that subject, we may then say that the above equations are absolutely true, if the series be carried *ad infinitum*. The general equation, made absolutely true, after stopping at ar^m in the series, is

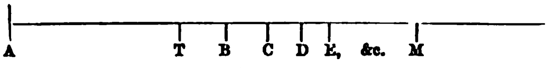
$$\frac{a}{1-r} = a + ar + \ldots + ar^m + \frac{ar^{m+1}}{1-r}.$$

Other points connected with this equation will be mentioned in the article SERIES.

There is no doubt that every whole can be subdivided into parts without limit, or, in common language, can be divided into an infinite number of parts. An old fallacy, mentioned in MOTION, receives its explanation from the preceding. If we make $a = 1 - r$, the equation carried *ad infinitum* becomes

$$1 = (1-r) + (1-r)r + (1-r)r^2 + , \&c., \textit{ad inf.}$$

By giving different values to r, we have therefore an infinite number of ways of subdividing unity into an infinite number of parts. If then we take a problem in which an antecedent is followed by a consequent; and if dividing the antecedent into an infinite number of parts, we consider separately the parts of the consequent which belong to those of the antecedent, we shall of course divide the consequent into an infinite number of parts. It would be a gross fallacy to infer that the consequent must be infinitely great, because it is produced in a never-ending succession of parts, since that never-ending succession was produced by dividing the avowedly finite antecedent into an infinite number of parts. No one could fail to detect the following :—"Let M be divided into an infinite number of parts, a, b, c, &c.; let each of these parts be doubled; then the result is made up of $2a$, $2b$, $2c$, &c., *ad infinitum*; consequently $2a + 2b + 2c +$, &c., being made up of an infinite number of quantities, is infinite." Nevertheless this fallacy was not only produced in an ingenious form, as a sophism [MOTION], but has even reappeared in modern times as a serious argument. The sophism is known by the name of "Achilles and the Tortoise." The swiftest of men runs after the slowest of beasts, without (says the sophism) the possibility of ever overtaking it. For if, when they set out, Achilles be at A and the tortoise at T, then by the time Achilles has run over AT, how fast soever he may run, the tortoise will have gone over some length, say TB; while the hero goes over TB, his dinner (for dinner he may have out of it, in spite of the sophism) goes over BC, and so on *ad infinitum*. How then, asks the objector, is it possible that Achilles can ever come up with the tortoise, since it is unquestionable (and this is perfectly correct), that let him go as far as he may, he must always come up to where the tortoise was before he can reach the point at which he is; so that it requires *an infinite number of parts of time* (but here the sophism quietly introduces *an infinite time*) to catch the tortoise? The answer is, that Achilles will certainly overtake the tortoise at a finite distance from A, say at M: any contrivance which subdivides AM into an infinite number of parts, does the same with the time in which Achilles runs over AM; and there is no more reason to say that the time is therefore infinitely great, than to say that AM is made infinitely great by the subdivision. This would be a sufficient answer, since it would throw upon the sophist the *onus* of showing that the infinite number of parts of time makes an infinite time; but a more complete answer consists in positive proof that it is not so, as follows :—



Let AT be called a, and let Achilles move m times as fast as the tortoise; then TB is necessarily the mth part of AT, BC of TB, CD of BC, &c. Hence, if t be the time in which Achilles moves over AT, this time, added to his times of going over TB, BC, CD, &c., or t, $t \div m$, $t \div m^2$, &c., make up

$$t\left(1 + \frac{1}{m} + \frac{1}{m^2} + \frac{1}{m^3} + \frac{1}{m^4} +, \&c., \textit{ad inf.}\right)$$

Now if m be greater than 1 (for unless Achilles move faster than the tortoise, it is admitted he can never catch it), the series above named is $1 \div \left(1 - \frac{1}{m}\right)$, so that the whole time is $tm \div (m-1)$, and the whole length AM is $am \div (m-1)$, the same answer as would be produced by common methods. The sophism divides this length into the infinite number of parts

$$a \qquad \frac{a}{m} \qquad \frac{a}{m^2} \qquad \frac{a}{m^3} \qquad \&c.$$

and taking the times due to each,

$$t \qquad \frac{t}{m} \qquad \frac{t}{m^2} \qquad \frac{t}{m^3}, \ \&c.,$$

assumes the sum of the latter to be infinite.

In the work of a celebrated political economist there is the following argument, to show that a tax on wages must fall on the labourers; for if it did not so fall, wages would rise, whence the price of goods would rise, which would again cause a rise of wages, and this again a rise in goods, and so on *ad infinitum*, which is inferred to be absurd. This is of course precisely a repetition of the preceding case; and granting all the premises, the conclusion by no means follows. For that conclusion is that the rise would go on without limit, which need not be the case.

The best way of remembering the summation of a geometrical series is by a verbal rule, as follows :—The sum is the difference between the first term *in* and the first term *out*, divided by the difference between the common multiplier and unity. Thus the sum of $30 + 90 + 270 + 810$ is $2430 - 30$ divided by $3 - 1$, or 1200.

PROHIBITION, a writ to prohibit a court and parties to a cause then depending before it from further proceeding in the cause. It will be convenient to define,—1, out of what courts it issues; 2, to what courts it may be addressed; 3, under what circumstances it is grantable; 4, at whose instance it may be obtained; 5, at what time it may be obtained; 6, the form and incidents of the proceeding.

1. A writ of prohibition usually issues from one of the three superior courts of common law at Westminster. It may issue from the Common-Law Court at Lancaster, and from the common-law side of the Court of Chancery.

2. It may be addressed to any other temporal court, such as to the Admiralty Courts, to Courts-Martial, to any inferior court in a city or borough, to the Duchy or County Palatine Courts, to the Stannary Courts, to the Commissioners of Appeals of Excise, to any court by usurpation without lawful authority, or to a court whose authority has expired. When any one has a citation to a court out of the realm, a prohibition lies to prevent his answering. It seems also that it might issue to the Court of Exchequer, and to the Court of Common Pleas; but not to the Court of Chancery; nor is there any instance of a prohibition to the King's Bench. It may be granted by any of the three superior common-law courts to any spiritual court, and by the common-law courts of Chester and Lancaster to the spiritual courts within the county palatine and duchy.

3. The writ is grantable in all cases where a court entertains matter not within its jurisdiction; or where, though the matter is within its jurisdiction, it attempts to try by rules other than those recognised by the law of England. Matter may be said to be not within the jurisdiction of a court in two senses: 1, when the subject-matter entertained is in its nature not cognisable by the court; 2, where the subject-matter is in its nature cognisable by the court, but lies out of the local district where only that court has jurisdiction; or, in the case of a court whose jurisdiction is general, when the subject-matter lies in a local district exempt from the general jurisdiction of the court, or where the subject-matter of the cause relates to persons over whom the court has no jurisdiction.

A prohibition will lie—to the courts of Admiralty, if they entertain questions of a contract made or to be executed within the kingdom; to the county court, if an action be brought in it on a judgment in one of the superior courts; to a spiritual court, if it takes cognisance of any plea concerning a title to an advowson, or an office, or goods, money, or chattels; and this applies even in the case of goods or ornaments given to a church, or matters of a criminal nature punishable only temporarily: in short, as it has been said, anything for which a remedy exists at common law.

Prohibition lies equally both where the matter of the suit is not cognisable by the court, and where, though the substance is cognisable, matter arises during the progress of it, and is clearly about to be tried, over which the court has no cognisance. Thus, if in a cause properly cognisable by a spiritual court, a question arises, and is necessarily about to be tried, as to the existence of a custom, or a prescription, or the limits of a parish, or where in a suit for tithes there is plea of a modus, or that the lands are discharged by statute, on tithes are claimed of things for which no tithes are due, or the defendant makes title by lease, &c., a prohibition will lie immediately. And a prohibition is in all cases grantable where a court allows illegal or disallows legal evidence, as where the Commissioners of Appeals for the Excise determine by the minutes of evidence taken by a justice of the peace, instead of examining the witnesses *vivâ voce*, or a spiritual court disallows proof of payment, &c., because proof of it is made only by a single witness, or where it has misconstrued an Act of Parliament, or disallows an award when it is good by law.

A prohibition will also lie where a court attempts to extend its jurisdiction to parties over whom it has none, as where a court-martial inquires into the conduct of a person not a soldier or sailor; the Stannary courts, where neither parties are tinners, nor the matter in question respecting tin, &c.

4. A prohibition may be obtained at the instance of either party to an ecclesiastical suit. In the case of a suit for tithes against a lessee it may be obtained by the reversioner. Where a court has no jurisdiction over the matter of the suit, a prohibition is grantable at the request of a mere stranger.

5. If a court has no cognisance of the matter of a suit, prohibition will lie immediately after appearance, and it may be obtained by either plaintiff or defendant at any future time, even after sentence, appeal, and affirmation; or after judgment and execution, provided it appears by the proceedings that the court had no jurisdiction. When the court has cognisance of a cause, prohibition will not lie until the matter out of its jurisdiction has not only arisen, but is also clearly in progress of being tried. If the matter is then admitted by the litigant parties, the court is still entitled to certain cognisance of the suit. If not admitted, and these circumstances, though not appearing on the face of the proceedings, are duly brought forward before judgment, a prohibition will then lie. If, however, a prohibition is not then applied for, but the party submit to the trial in the court where the suit has been commenced and judgment is pronounced, no prohibition will lie unless it appear on the proceedings, not only that matter out of the jurisdiction of the court has arisen, but also that the matter has been wrongly decided. These observations only apply to permanent courts, and where something still remains to be done. In the case of an occasional court, as a court-martial, it would be impossible to carry the principle into execution.

6. A writ of prohibition is applied for by motion in court, which sets out the proceedings in the suit. If the proceedings are not sufficient to show the want of jurisdiction in the court against which prohibition is prayed, suggestions must be added, verified by affidavit, showing such want of jurisdiction.

If the court grants a rule, the other party is heard in answer. The court may then decide, either to refuse the prohibition, or, if they incline to grant it, direct the party applying to declare in prohibition. The declaration must contain a concise statement of the grounds of the application, and conclude by praying that the writ may issue. To this the other party may demur on the ground that no sufficient cause appears for a prohibition, or he may plead such matters as he thinks proper to show that the writ ought not to issue, and conclude by praying that it may not issue. If matters of fact are put in issue, they are tried by a jury. Judgment is given either on the demurrer or after nonsuit or verdict. The party succeeding is entitled to the costs of these proceedings, and, if a trial takes place, the jury may assess damages. If the court decide in favour of the party applying, the writ issues and forbids the court and other party from further proceeding. In such cases, if the ground of application was that the court had no jurisdiction at all in the suit, the writ of prohibition is final. But if the ground is that something had arisen not cognisable by the court, during the progress of a suit, concerning a matter properly within its jurisdiction, the prohibition is not final. In such case the question is referred to the proper tribunal for trial, and if found against the applicant, the suit may be then resumed. In either case, where the court decides in favour of the party against whom prohibition is prayed, or the verdict has been afterwards in his favour, the court awards a consultation, as it is called, by which the cause is again remitted to the original court. If parties proceed after a writ of prohibition has been obtained and served, they are liable to an attachment for contempt. No prohibition for the same matter lies after a consultation has been awarded upon the merits.

There can be no pleadings in a prohibition to the County Courts, the merits of which must be determined on the application for the writ.

(Comyns's *Digest*; 2 *Inst.*, 599; 3 Blackst.'*Com.*, Mr. Kerr's ed., c. 7.)

The right of the common-law courts to issue writs of prohibition, and the mode in which they exercised that right, have often been the subject of great dispute between the common-law judges and the ecclesiastics. The latter have several times exhibited many articles of grievance before the parliament and privy council against the former. The most famous of these are the 'Articuli cleri,' exhibited by Archbishop Bancroft, in the name of the whole clergy, in the third year of the reign of James I. They are given at length by Lord Coke (2 'Inst.,' 599), with a full view of the nature of the controversy between the parties and the unanimous answers of the judges.

PROJECTILES, THEORY OF. This subject usually comprehends the investigation of the relations between the space described, the time of motion, and the velocity acquired by a body when impelled in any direction by some motive force.

The circumstances of a body descending from a high place towards the earth by the action of gravity, and those of a body projected vertically upwards from the earth, on the supposition, in both cases, that the body moves in a non-resisting medium, have been noticed in the article FALL OF BODIES; and the circumstances attending the motion, both in a resisting and a non-resisting medium, of a body impelled by fired gunpowder, when the impulse is in a direction parallel or oblique to the horizon, have been investigated in the article GUNNERY. It is intended therefore in this place only to consider the laws of the vertical ascent and descent of bodies in resisting media, the force of gravity, or of terrestrial attraction, being supposed to be constant; and in non-resisting media, under the condition that the force of gravity is variable.

Let a spherical body descend vertically from a state of rest in a resisting medium (air, water, &c.) supposed to be of uniform density; and let it be admitted, agreeably to the Newtonian hypothesis ('Princip.', lib. ii. sec. 1; *Schol.*), that the resistance of the medium is proportional to the square of the velocity, v, acquired at any moment in the descent; then, if we suppose U to be the velocity which a body falling towards the earth in the resisting medium would acquire when that resistance becomes equal to the accelerative force of gravity, the latter being, as usual, represented by g (=32·2 feet), we shall have $\mathrm{U}^2 : g :: v^2 : \frac{v^2}{\mathrm{U}^2}g$; and the last term represents the resistance of the medium at the instant when the velocity is v; hence the accelerative force by which the falling body is urged at such moment is expressed by $g - \frac{v^2}{\mathrm{U}^2}g$.

Now s being the space descended by the body in the time t, and v being the velocity as before, an accelerative force is represented by $\frac{dv}{dt}$ and by $\frac{d^2s}{dt^2}$. [FORCE.] Therefore $\frac{dv}{dt} = g - \frac{v^2}{\mathrm{U}^2}g$; whence $gdt = \frac{dv}{1 - \frac{v^2}{\mathrm{U}^2}}$; and integrating this equation, observing that $v = 0$ when $t = 0$, we have $t = \frac{\mathrm{U}}{2g}$ hyp. log. $\frac{\mathrm{U}+v}{\mathrm{U}-v}$, or $\frac{2gt}{\mathrm{U}}$ = hyp. log. $\frac{\mathrm{U}+v}{\mathrm{U}-v}$; or again, passing from logarithms to numbers, $\frac{\mathrm{U}+v}{\mathrm{U}-v} = e^{\frac{2gt}{\mathrm{U}}}$ (e being the base of the hyperbolic logarithms); whence $v = \mathrm{U}\frac{e^{\frac{2gt}{\mathrm{U}}} - 1}{1 + e^{\frac{2gt}{\mathrm{U}}}}$, and this second member being developed, gives $v = gt - \frac{g^3t^3}{3\mathrm{U}^2} + \&c.$ Substituting, in this equation, $\frac{ds}{dt}$ for v, and again integrating, we have $s = \frac{1}{2}gt^2 - \frac{g^3t^4}{12\mathrm{U}^2} + \&c.$

These equations for s and v give the space descended and the velocity acquired at the end of any given time t from the moment when the motion commenced. For tables of the values of U (the terminal velocities) for iron balls, see Dr. Hutton's Tracts, tract 37.

Next, let a body be projected vertically upwards in a uniformly resisting medium with an initial velocity = V; and let the body be of a spherical form so that U may be the same as before: then, the force of gravity and the resistance of the medium acting in a direction opposite to that of the projectile force, we have now $\frac{dv}{dt} = -g - \frac{gv^2}{\mathrm{U}^2}$; whence $-gdt = \mathrm{U}\frac{d.\frac{v}{\mathrm{U}}}{1 + \frac{v^2}{\mathrm{U}^2}}$. This equation, being integrated, gives $-gt = \mathrm{U}$ arc tan. $= \frac{v}{\mathrm{U}}$ + *const.*; and considering that $v = \mathrm{V}$ when $t = 0$, the constant is equal to $-\mathrm{U}$ arc tan. $= \frac{\mathrm{V}}{\mathrm{U}}$; putting $-\mathrm{C}$ to represent this term, we have $\frac{\mathrm{C} - gt}{\mathrm{U}}$ = arc tan. $\frac{v}{\mathrm{U}}$; and passing from arcs to tangents, we have $\frac{v}{\mathrm{U}}$ = tan. $\frac{\mathrm{C} - gt}{\mathrm{U}}$, or $v = \mathrm{U}$ tan. $\frac{\mathrm{C} - gt}{\mathrm{U}}$. Multiplying both members of the last equation by vdt, and putting dx for its equal vdt, this equation becomes $dx = \mathrm{U}$ tan. $\frac{\mathrm{C} - gt}{\mathrm{U}}\,dt$; which integrated gives $x = \frac{\mathrm{U}^2}{g}$ hyp. log. cos. $\frac{\mathrm{C} - gt}{\mathrm{U}}$ + *const.*; The constant is determined by considering that $x = 0$ when $t = 0$; whence *const.* $= -\frac{\text{U}^2}{g}$ hyp. log. cos. $\frac{\text{C}}{\text{U}}$: therefore $x = \frac{\text{U}^2}{g}$ hyp. log. $\dfrac{\cos. \dfrac{\text{C} - gt}{\text{U}}}{\cos. \dfrac{\text{C}}{\text{U}}}$

Making $v = 0$ in the above equation for v, we get the value of t when the body has attained its greatest height; and substituting the value of t so found in the last equation for x, we have that greatest height.

When arrived at the greatest height, the body would begin to return towards the earth; and it may be shown that the velocity acquired by the body on arriving at the place from whence it was projected would be less than the initial velocity; also that the time of the descent would differ from the time of ascent.

If we imagine the earth to be perforated in the direction of a diameter; and if a body be allowed to descend towards the centre in a non-resisting medium from any point in the line of perforation: the law of attraction being in such a case directly proportional to the distance of the body at any time from the centre of the earth (Newton, lib. i. prop. 73), the relation between the space descended and the time of descent may be thus investigated.

Let r be the radius of the earth, and let the force of gravity at the surface be represented by g; then x being any distance from the centre, the attracting force acting on the body at that distance will be $\frac{gx}{r}$. Therefore since the distance of the body from the centre diminishes, while the time reckoned from the moment of departure increases, we shall have $\frac{d^2x}{dt^2} = -\frac{gx}{r}$. This equation will be found to be verified by assuming $x = a \cos. t\sqrt{\frac{g}{r}} + b \sin. t\sqrt{\frac{g}{r}}$; which being differentiated once, gives $\frac{dx}{dt} = -a\sqrt{\frac{g}{r}} \sin. t\sqrt{\frac{g}{r}} + b\sqrt{\frac{g}{r}} \cos. t\sqrt{\frac{g}{r}}$. Now, in the equation for x, making $x = r'$ (any given distance from the centre) when $t = 0$, we have $a = r'$; and in the equation for $\frac{dx}{dt}$, making $\frac{dx}{dt}$ (the velocity) $= 0$ when $t = 0$, we have $b = 0$. Consequently $x = r' \cos. t\sqrt{\frac{g}{r}}$; whence x is found when t is given: but when $x = 0$, we have $t\sqrt{\frac{g}{r}} = \frac{\pi}{2}$ (where π represents the half circumference of a circle whose radius is equal to unity) whatever be the value of r'. Therefore $t = \frac{\pi}{2}\sqrt{\frac{r}{g}}$ will express the time of falling from the surface to the centre of the earth.

Let it now be required to investigate the relations between the times, the spaces described, and the acquired velocities when a body falls in vacuo from a point at such a distance from the earth that the attraction of gravity upon it may be considered as variable; and when, agreeably to the law of nature, its intensity is inversely proportional to the square of the distance. ('Princip.,' lib. i., prop. 74.) Then, if r be the radius of the earth, p the distance from the centre of the earth to the point above the latter from whence the body is let fall; and if x be the space descended in any time t: also if g be the force of gravity at the earth's surface, we shall have $\frac{1}{r^2} : g :: \frac{1}{(p-x)^2} : \frac{r^2g}{(p-x)^2}$; and the last term expresses the force of gravity at the place of the body when the space descended is x and the time of descent is t: therefore $\frac{d^2x}{dt^2} = \frac{gr^2}{(p-x)^2}$.

In order to integrate this equation, multiply both sides of it by $2dx$; and then the first integral will be $\frac{dx^2}{dt^2} = \frac{2gr^2}{p-x} + \textit{const.}$ The constant may be found on considering that $\frac{dx}{dt}$ (the velocity) $= 0$ when $t = 0$, when also $x = 0$; therefore *const.* $= -\frac{2gr^2}{p}$, and $\frac{dx^2}{dt^2} = 2gr^2\left(\frac{1}{p-x} - \frac{1}{p}\right)$; whence $\frac{dx}{dt} = \sqrt{\left\{\frac{2gr^2}{p} \cdot \frac{x}{p-x}\right\}}$. This equation may be put in the form $\frac{(p-x)\,dx}{\sqrt{px-x^2}} = \frac{2gr^2}{p}\,dt$; and by the rules of integration we have $t\sqrt{\frac{2gr^2}{p}} = \sqrt{px-x^2} + \frac{1}{2}p \text{ arc cos.} = \frac{p-2x}{p}$: there is no constant to be added, because $x = 0$ when $t = 0$. From this equation t may easily be found when x is given: likewise from the equation for $\frac{dx}{dt}$ we have the velocity when x is given. And if x be made equal to $p-r$, the whole distance of the body from the surface of the earth, we shall obtain the whole time of the descent and the velocity acquired at the end of that time.

Again: let it be supposed that a body may be projected vertically upwards in vacuo from the surface of the earth, and be subject to a variably accelerative force of attraction downwards. Let r be the semidiameter of the earth as before; and now let x be the height ascended from the surface at the end of the time t: also let h be the height due to the initial velocity, supposing the latter to have been acquired by a body falling in vacuo with a uniformly accelerative force; then $2gh$ will express the square of that velocity. By the law of attraction we have $\frac{1}{r^2} : g :: \frac{1}{(r+x)^2} : \frac{gr^2}{(r+x)^2}$; and the last term expresses the intensity of the attractive force at the end of the time t from the commencement of the ascent. Hence $\frac{d^2x}{dt^2} = \frac{gr^2}{(r+x)^2}$.

In order to integrate this equation, multiply both sides by $2dx$; then we get $\frac{dx^2}{dt^2} = -\frac{2gr^2}{r+x} + \textit{const.}$: and to find the constant, it must be observed that $x = 0$ when $\frac{dx^2}{dt^2} = 2gh$; therefore *const.* $= 2g(h+r)$ and $\frac{dx^2}{dt^2} = 2g(h+r) - \frac{2gr^2}{r+x}$, or $= \frac{2g\{hr + (h+r)x\}}{r+x}$. Taking the square roots and transposing, we have $\frac{\sqrt{r+x}}{\sqrt{\{hr+(h+r)x\}}}\,dx = \sqrt{2g} \,.\, dt$, and this equation may be put in the form

$$\frac{(r+x)dx}{\sqrt{\{hr^2 + (2h+r)rx + (h+r)x^2\}}} = \sqrt{2g} \,.\, dt;$$

or (h being small compared with r) rejecting h when added to r, the equation becomes

$$\frac{(r+x)dx}{\sqrt{\{hr^2 + r^2x + rx^2\}}} = \sqrt{2g} \,.\, dt.$$

Now, multiplying the numerator and denominator of the first member by $2r$, and putting the whole in the form

$$\frac{(r^2+2rx)dx}{2r\sqrt{\{hr^2+r^2x+rx^2\}}} + \frac{r\,dx}{2\sqrt{\{hr^2+r^2x+rx^2\}}} = \sqrt{2g} \,.\, dt,$$

the rules of integration give

$$\frac{1}{r}\sqrt{\{hr^2+r^2x+rx^2\}} + \frac{\sqrt{r}}{2} \text{ hyp. log.}\left\{\frac{r^{\frac{3}{2}}}{2} + x\sqrt{r} + \sqrt{\{hr^2+r^2x+rx^2\}}\right\} + \textit{const.} \sqrt{2g}\;\; t.$$

The constant may be determined by considering that $x = 0$ when $t = 0$; and thus t may be found when x is given.

What has been stated respecting the vertical descent and ascent of bodies may be understood to apply also to bodies descending and ascending on inclined planes; the force of gravity on the plane being represented by $g \sin. a$, where a is the inclination of the plane to the horizon.

In Dr. Hutton's Tracts there is given a problem for determining the height ascended by a ball when projected vertically upwards with a given velocity, and resisted by the air; the force of gravity being supposed to be constant, and allowance being made for the decrease in the density of the air as the ball ascends. (Tract 37, prob. v.) In the same tract there is also given (prob. xi.) an investigation of the circumstances attending the motion of a body in air when projected horizontally on a smooth surface so that the action of gravity may produce no effect on the motion of the body, the resistance varying as the square of the velocity. Also in Poisson's 'Traité de Mécanique,' the following remarkable circumstance is demonstrated:—If a body be projected, as in the last case, and if the resistance of the air vary as the square root of the velocity; the motion of the body will at first diminish gradually till it becomes equal to zero; and afterwards it will go on increasing indefinitely. ('Tom.' i., no. 136, ed. 1833.) But for the demonstrations of these problems our limits oblige us to refer the reader to the works just mentioned.

PROJECTION. The practical parts of this most important application of geometry are noticed in the articles MAP; PERSPECTIVE; GNOMONIC; GLOBULAR; ORTHOGONAL, ORTHOGRAPHIC; STEREOGRAPHIC; &c. The present article is merely intended to point out the general principle of all projections, and also to note the theoretical importance of the subject.

Imagine a surface of any kind, through every point of which passes a curve the character of which depends upon that point, insomuch that, given a point of the surface, the curve which passes through that point is given in character and position. If any second surface be taken, which is cut by all the curves emanating from the points of the first, every point of the first surface has a point corresponding to it on the second. Thus if the curve passing through A on the first surface cut the second surface in a, the point A is said to be projected on the second surface at a by means of the projecting curve A a. Similarly any line on the first surface is projected into a line on the second, which last contains the projections of all the points on the first; and the projections of the several boundaries of a figure on the first surface are boundaries of a figure on the second, which is the projection[*] of the first figure.

It is perhaps not usual to make so wide a definition of projection in general, since the only cases which are commonly considered are those in which the projecting lines are all straight, and either parallel to one another, as in the orthographic projection, or all passing through the same point, as in common perspective. But such a conception of projection is necessary: in Mercator's projection, for example, [MAP] the points of a sphere are projected on a circumscribing cylinder, not by straight lines passing through a point, but either by straight lines disposed according to a complicated law, or else by curves. If a relation between any point and its projection be given, so that either can be found from the other, the passage from one to the other may be made either on a straight line or on an infinite variety of curves; but it may happen that the law which the disposition of the projecting straight lines follows may be of a more difficult character than that which would be required if a curve, not in itself so simple as a straight line, were substituted.

When the foundations of plane geometry were fixed, and the first principles of solid geometry were superadded, it was natural that the very simple idea of the perspective projection should excite attention. In a country in which the first principles at least of drawing were practically known, the following problem must have suggested itself to the geometers: If through a given point lines be drawn through all the points of the boundary of a plane figure, until they are stopped by another plane, required the figure traced out upon the second plane. A straight line was known thus to give a straight line: a moment's consideration of the circle, the only other line then considered, would show that a projection of a circle and a plane section of a cone are the same things. Hence probably the first idea of a conic section; and thus, if the conjecture be correct, the attention was turned from that point, which would, if properly kept in view, have led to the theory of projections in place of one isolated branch of it. The properties of the conic sections, as deduced in the ancient manner from the cone, are neither so general nor so easy as they might be made; and it may be confidently expected, considering the progress which the doctrine of projections has made of late years, that the method of considering the ellipse, hyperbola, and parabola as projections of the circle, will become established in elementary teaching, in preference to the detached geometrical and algebraical methods now in use.

We have already spoken of the geometry of projections [GEOMETRY]: unfortunately there is no elementary work which gives a general view of its first principles supported by sufficient application; and until such a work shall appear, the student must search for himself the writings of Monge, Carnôt, Chasles, Poncelet, &c. The 'History of Geometry,' by M. Chasles, referred to in the article cited, will furnish many more references; and the 'Propriétés Projectives des Figures,' by M. Poncelet, is perhaps the work in which the student may most easily make an advantageous beginning of the subject. Much has been done of late years to introduce some elements into works on the conic sections: but projection has not yet been properly treated as a distinct subject.

The basis of the theory of projections must be the investigation of properties which, being true of a figure, are therefore true of its projections. Some of these are evident enough: thus the projection of an intersection of two lines is the intersection of their projections; if two curves touch one another, their projections touch at a point which is the projection of the point of contact. But the following property, which is projective, that is, true of the projections of every figure of which it is true in the first instance, will give a good idea of the facility with which certain properties of the conic sections may be deduced from the circle.

Let there be any figure in which the product of certain straight lines is equal to, or in any absolutely given ratio to, the product of certain others, each line being denoted by an initial and terminal letter in the usual way. We might say, in more geometrical language, let there be any number of ratios which, compounded together, give either a ratio of equality or a given ratio. Two simple conditions being fulfilled, this property will be as true of the projections as it is of the figure itself. These conditions are, first, that every initial and terminal letter shall occur the same number of times on both sides of the equation; secondly, that for every line on the first side, there shall be a distinct line on the other side, which is in the same straight line. For example (the reader may draw the diagram for himself), let each of the sides of the triangle ABC cut one circle, namely, AB in P and Q, BC in R and S, CA in T and V; the order of the points being APQBRSCTVA. Then by the properties of the circle, it is easily seen that

$$AV.\,AT.\,CS.\,CR.\,BQ.\,BP = AP.\,AQ.\,BR.\,BS.\,CT.\,CV.$$

In this equation, A, B, and C occur twice on each side, and each of P, Q, R, S, T, V, once. Moreover, out of AB there are two segments, AP and AQ, on the first side, and as many, BQ and BP, on the second; and the same of BC and CA. He then who is acquainted with the theory of projections, immediately knows that this property is true of any projection of a circle, or of any conic section: but he would be an energetic algebraist who should attempt to prove this (or still more the equally demonstrable similar property in the case of a polygon of n sides) by the common algebraic methods.

The proof of the preceding general *projective* property is not difficult. Take a point O outside the plane for the centre of projection, and let $OA=a$, $OB=b$, &c.; moreover let the angle made by a and b be called (ab). Let A', B', &c., be the projections of A, B, &c., let $OA'=a'$, $OB'=b'$, &c., and let $(a'b')$ be the angle of a' and b', which is $=(ab)$. Moreover let $[AB]$ mean the perpendicular let fall from O upon AB, &c. It is then easily proved that

$$AV=\frac{av.\ \sin\,(av)}{[AV]},\quad AT=\frac{at.\ \sin\,(at)}{[AT]},\ \&c.$$

Substitute these values in the equation, and it will be readily seen that the existence of the two conditions above named amounts to all the quantities except the sines of the angles being eliminable by division. There remains then

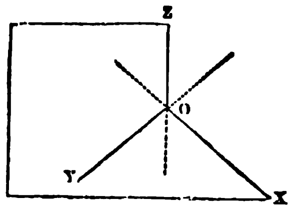
$$\sin\,(av).\ \sin\,(at).\ \&c. \;=\; \sin\,(ap).\ \sin\,(aq).\ \&c.$$
$$\text{or } \sin\,(a'v').\ \sin\,(a't').\ \&c. \;=\; \sin\,(a'p').\ \sin\,(a'q').\ \&c.$$

In this write a', b', $[A'V']$, &c., where there were previously a, b, $[AV]$, &c., which will amount (by the conditions) to multiplying both sides by the same quantities: there will then remain an equation which is obviously

$$A'V'.\ A'T'.\ \&c. = A'P'.\ A'Q'.\ \&c.,$$

and in the same way any other case may be proved.

PROJECTION OF MATHEMATICAL DIAGRAMS. The diagrams by which mathematical students (and even writers) represent their solid figures are generally so imperfect, that it may be worth while to explain how, in all cases of sufficient importance, a good drawing may be made with very little trouble. The demonstration may be found in the 'Cambridge Mathematical Journal,' No. 8, p. 92. The projection is supposed to be the ORTHOGRAPHIC, in which the eye is at an infinite distance, and all parallels are projected into parallels, &c.



Let OX, OY, OZ, be the intended projections of the three axes of co-ordinates, the dark lines being supposed to belong to that quarter of space in which lies a line drawn to the eye from the origin O. Each of the angles YOZ, ZOX, XOY, is then greater than a right angle. The following table contains numbers sufficiently near for the purpose, proportional to the square roots of the sines of twice the angles written in the opposite columns.

° °		° °		° °	
90—180	000	105—165	707	120—150	931
———	132	———	718	———	935
91—179	187	106—164	728	121—149	940
———	229	———	738	———	944
92—178	264	107—163	748	122—148	948
———	295	———	757	———	952
93—177	323	108—162	767	123—147	956
———	349	———	776	———	959
94—176	373	109—161	785	124—146	963
———	396	———	793	———	966
95—175	417	110—160	802	125—145	969
———	437	———	811	———	972
96—174	456	111—159	818	126—144	975
———	474	———	826	———	978
97—173	492	112—158	834	127—143	980
———	509	———	841	———	983
98—172	525	113—157	848	128—142	985
———	541	———	855	———	987
99—171	556	114—156	862	129—141	989
———	571	———	869	———	991
100—170	585	115—155	875	130—140	992
———	599	———	882	———	994
101—169	612	116—154	888	131—139	995
———	625	———	894	———	996
102—168	638	117—153	900	132—138	997
———	650	———	905	———	998
103—167	662	118—152	911	133—137	999
———	674	———	916	———	999
104—166	685	119—151	921	134—136	1000
———	696	———	926	———	1000
				135—135	1000

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[*] The projection of a line or figure has seldom any other name; in astronomy however, the projection of a planet's distance from the sun on the plane of the ecliptic is sometimes called the *curtate* distance.

The lines between the degrees are to be understood as representing half degrees: thus opposite to 991 should come 129½°—140½°. The use of this table is as follows:—suppose the angles Y O Z, Z O X, X O Y, to be severally 123°, 104½°, and 132½°: thus:—

Y O Z = 123°	956	*x*
Z O X = 104½°	696	*y*
X O Y = 132½	998	*z*

Opposite to the angles put down the numbers belonging to them in the table, and opposite to each number the co-ordinate whose capital letter does not appear in the angle. Then opposite to *x*, *y*, and *z*, we have 956, 696, and 998. These numbers show the proportions which the projections of equal lines bear to one another on the three axes. Thus a foot parallel to *x* is to a foot parallel to *y*, as 956 to 696 in the projection. If then a card be taken, and the angle Z O X be cut out; and if a slit be made in the direction of O Y, just wide enough to permit a pencil to travel, scales of equal parts may be laid down on O X, O Y, and O Z, which shall represent the projections of equal lines in the three directions; and this may be done once for all. It would be easy enough to make a general scale by which the equal parts proper for any angle should be taken out at once.

The isometrical perspective of Professor Farish [PERSPECTIVE, col. 416] is the simplest case of this, namely, that in which the angles are each 120°. The only difference between this particular case and any other is, that the former requires only one scale of equal parts, whereas the latter requires either two or three. In other respects this method of using them is precisely the same.

PROJECTION OF THE SPHERE, SHADOWS, &c. [PERSPECTIVE.]

PROLOCUTOR. [CONVOCATION.]

PROLOGUE (πρόλογος, from πρὸ, *before*, and λόγος, *speech*), is usually applied in English to the short poem or verses, which are sometimes prefixed to new plays to recommend them to the favour of the reader or spectators. In the comedies of Plautus and Terence we find prologues of this kind. Aristotle ('Poetik.' c. 12), gives the name of prologue to that part of the Greek tragedy which precedes the parodos, or first speech of the chorus.

PROMETHEUS (Προμηθεύς). The story of Prometheus takes different forms in the Greek legends, but they agree generally in representing the close connection between him and the human race. He is represented by Æschylus as one of the Titans, who incurred the resentment of Zeus for taking the part of mortals when Zeus intended to crush them and to send them to the abode of Hades, and also for giving them fire and teaching them all the arts. As a punishment, Zeus binds him to a rock in Scythia, and appoints a vulture to prey on his liver. This is the subject of the 'Prometheus Desmotes,' or 'Prometheus Bound,' of Æschylus.

Another old form of the legend, which closely resembles that which Æschylus followed, is given in the 'Theogony' of Hesiod. Hesiod says that when the gods and men were engaged in a controversy with one another at Mecone (an ancient name of Sicyon), Prometheus, wishing to deceive Zeus, took an ox, and dividing it, placed the flesh and the viscera in the hide, and the bones of the ox in the inside fat, and then asked Zeus to make his choice. Zeus, though aware of the deception, chose the bones and the fat, "designing evil in his mind against mortal man," and in revenge withheld fire from man. Prometheus however secretly stole fire from heaven and gave it to man, and Zeus in return bound Prometheus with chains to a pillar, and sent an eagle to prey upon his liver. Zeus also, in order to injure man, created Pandora, and, after bestowing upon her numerous gifts, sent her to man a "beautiful mischief, for from her is sprung the race of women, of whom the race is thoroughly destructive." Hesiod, in his poem entitled 'Works and Days,' gives at greater length the legend of Pandora, and says that Zeus sent her to Epimetheus; and that he, not following the advice of Prometheus, who had told him never to receive a gift from Zeus, but to send it back again, took her into his house. These stories are supposed to have a meaning: Prometheus is the personification of *fore-thought*, and Epimetheus of *after-thought*.

There is another form of the legend respecting Prometheus, in which he is represented not merely as the friend and protector of the human race, but as their creator. This form is an old one, though neither Hesiod nor Æschylus has followed it. There is a fragment of Callimachus, in which he says, "If Prometheus formed thee, and thou art not sprung from some other clay." Plato has adopted this form of the legend in the 'Protagoras,' but with the variation that Prometheus is not the creator, but only the person who endowed man with his senses. He says that the gods formed all mortal animals within the earth, out of the mixture of earth and fire, and of as many things as are mingled with earth and fire, and that they entrusted to Prometheus and Epimetheus the business of providing them with all the faculties necessary for their preservation. He then proceeds to say that Epimetheus begged of Prometheus that he might have the business himself in the first place, and that Prometheus should overlook his work when he had done it. Epimetheus accordingly proceeds to his work, and bestows upon the different animals the means of preserving themselves; but when man came to be provided for, who was to be superior to all other animals, Epimetheus had been so prodigal of all his resources, that he had nothing left to bestow upon man. Prometheus, being at a loss how to remedy the omission of Epimetheus, steals from Hephæstus and Athena fire and the intelligence which is displayed in works of art, and gave them to man; so that by means of this wisdom, and fire as its instrument, men were endowed with the power of providing for themselves.

Some modern writers suppose that, in the earliest form of the legend, Prometheus was not considered as a deity, but simply as the representative of the human race, and that afterwards he was made a god, the friend and protector of man, and at last their creator.

Representations of Prometheus are frequent in the latter ages of ancient art, especially in allegorical representations of human life on sarcophagi, and in connection with the Fates, Eros and Psyche, and other legends. (Müller, 'Archäologie der Kunst,' § 396.)

PROMISSORY NOTE. [BILL OF EXCHANGE.]

PROMULGATION. Promulgation is from the Latin Promulgo, which is equivalent to Provulgo, and means "to make public." Blackstone observes of the promulgation of a law, "It may be notified by universal tradition and long practice, which supposes a previous publication, and is the case of the common law of England. It may be notified *vivâ voce* by officers appointed for that purpose, as is done with regard to proclamations, and such acts of parliament as are appointed to be publicly read in churches and other assemblies. It may lastly be notified by writing, printing, or the like, which is the general course taken with all our acts of parliament." A law being a command from a political superior to a political inferior to do or not to do something, with a penalty attached to the violation of the command, it is assumed that the command is made known in some way to all who are bound to obey it; or that it is known to all. But as to "a universal tradition and long usage," it is a mistake to say that it supposes a previous publication. A long usage does not of itself make law: the usage must be pronounced to be law by some competent authority, and that is the only promulgation which it has. Promulgation by proclamation only reaches those who hear it, and everybody cannot hear an act of parliament which is read in churches, for the churches would not hold one-fourth of the people if they all went to hear it read; and if they heard it read, very few would understand it. Printing is at present the most efficient means of promulgating a new statute; but to all those who cannot read it is ineffectual; and so it is indeed to those who cannot understand it, which sometimes the judges themselves say they cannot do.

No remedy can be provided for these difficulties, and it is simply a positive rule of law that a new statute is binding on all persons who are under the authority of the power which makes the statute, from the moment that the statute is made and completed in due form. A person is presumed to know the law, because if he were allowed to urge ignorance of it as an excuse, it might be urged in so many cases as to give unbounded room for fraud. The positive rule that all the members of a state are bound by its laws, causes less evil than the admission of the excuse would.

Promulgation of a law among the Romans meant the placing of the bill (rogatio) in some public place where it could be read before it was voted upon in the Comitia. The Roman rule, which we also adopt, was that ignorance of law (ignorantia juris) was no excuse. (Paulus, *Dig.* 22, tit. 6. s. 9.)

PRONOUNS, the name given by grammarians to certain words which are used as substitutes for the names of persons and things. Pronouns properly so called are commonly divided into personal, demonstrative, relative, and interrogative pronouns; but it appears probable that all pronouns, at least with the exception of the first and second personal pronouns, were originally demonstrative. William Humboldt remarks that the first and second personal pronouns "are not mere substitutes for the names of the persons for whom they stand, but involve the personality of the speaker and of the person spoken to, and the relation between them;" and in writing and conversation there is frequently hardly any name which can so clearly designate the person intended as the appropriate personal pronoun. The third personal pronoun in English appears to have been originally a demonstrative, and to contain the same root, *ta*, *sa*, or *ha*, which occurs in the demonstrative pronoun in the Latin, Greek, and other cognate languages.

The relative pronoun may also be regarded as a demonstrative; for whether the pronoun is used to denote an object pointed out at the time by the speaker, or an object mentioned just before, or one which is to be immediately brought before the hearer's mind, it is equally demonstrative. In the last of these cases the pronoun is called a relative, as "I saw the man *whom* you mentioned." In English we have two forms for the relative, *that* and *who* or *which*. The former is the same word as the demonstrative; the latter contains the same root as we find in the Latin *qui*, the Sanscrit, Zend, and Lithuanian *ka*, and the Gothic *hver* and *hva*. The interrogative pronoun is the same as the relative in English and many of the cognate languages, and only differs from the relative in referring to something subsequent and unknown; whereas the latter refers to an antecedent and definite subject.

PRONUNCIATION. [ORATORY.]

PROOF. [DEMONSTRATION; EVIDENCE; MIRACLE; OATH; PROBABILITY.]

PROOF SPIRIT. A mixture of equal parts of water and alcohol is generally so termed, but legally proof spirit is defined by act of parliament to be "such as shall, at the temperature of 51° Fahr., weigh exactly $\frac{12}{13}$ths of an equal measure of distilled water." Such a mixture consists by weight of 50·76 water, and 49·24 alcohol; and its specific gravity is ·920. [ALCOHOL.]

PROPELLER. In works upon the construction of machinery the word *propeller* is used to indicate the arrangement by means of which motion is given to a carriage bearing a portion of the working gear required to traverse regularly in a horizontal direction; or to indicate a peculiar mechanism, set in motion by some mechanical power in vessels or ships which causes the latter to advance by the resistance offered by the water. The former class of propellers are most frequently employed in tools, and metal-working machinery, and consist of a fixed shaft bearing a screw thread, gearing into a nut working upon guides, so as only to be able to move laterally. The latter are more numerous, and may be said to consist of oars, sails, paddle-wheels, and screw-propellers. Sometimes the locomotive engine is used to propel loads on land; but this is so manifestly a modification of its tractive powers that it may for the present at least be neglected. Attention will in the following article be principally called to the propellers used for steam navigation, unquestionably the most important machines of this description now in use.

Until the application of the steam engine to the purposes of navigation, oars and sails were the only propellers used. Oars are, in fact, levers worked by hand against a fulcrum fixed on the boat itself, and causing the latter to advance by the reaction of the water upon the boat. Sails are propellers by reason of the resistance they offer to the movement of the wind, which thus exercises a motive power upon the vessel by its transmission to the hull, through the masts. Accordingly, therefore, as the sails are fixed with regard to the longitudinal axis of the ship, do they cause it to advance either in the line of the keel, to drop to leeward, or to turn on its vertical axis, with a velocity depending upon the size of the sails, the velocity of the movement of the wind, and upon the shape of the vessel. These various conditions come more especially under the province of ship-building, or of navigation, and are therefore only alluded to here incidentally.

The use of wheels bearing floats working in the water by the side of the boats to which they were fixed, had been known from a very remote period; but it was not until the steam engine was applied as a motive power to them that they were commonly introduced as propellers. At the present day the majority of steam-boats designed to work in comparatively still water, and even the majority of the vessels used in the deep-sea packet service, are provided with these organs of locomotion. It is found, indeed, that paddle-wheel steamers can attain a greater economical velocity than screw steamers hitherto have done; and the noise and vibration of the screw renders the class of vessel to which it is applied so uncomfortable, that it cannot be considered applicable to passenger traffic. Upon some rivers and large artificial canals, the waves caused by paddle-wheels are thought to be so injurious to the banks, that screw-propellers are substituted for them; but the agitation of the water below the surface produced by the revolution of the screw seems to be nearly as mischievous as the surface waves caused by the paddles; so that the most important advantage possessed by the screw propeller over the paddle-wheel, for narrow water-courses, finally resolves itself into the smaller width it allows to be given to the vessel. In deep-sea-going vessels, which do not carry passengers, the advantages of the screw are so great that nearly all the new traffic steamers are fitted with propellers of that description; and the company founded by Mr. Smith, in 1836, which built the Archimedes, has indeed already changed the whole condition of our commercial marine.

When paddle-wheels are used as propellers, they are placed upon a horizontal shaft or axis, and in front of the centre of gravity of the vessel; but there does not yet seem to be any uniformity of practice amongst constructors with regard to the precise position of those parts of the machinery; and even in the case of some of the canal boats used in Belgium the wheels are fixed at the stern, without any apparently disadvantageous results. In sea-going boats the wheels are, however, always placed on the outside, and about the middle of the boat; they are keyed upon a horizontal shaft bearing upon the solid framework of the ship's side, and almost always upon an external seating, carried by the framework of the paddle-box. The paddle-wheel shaft is continuous through the vessel when only one engine is used, and it is made in two pieces, with a movable clutch or coupling joint, when two engines are required, as is the case in all sea-going vessels. Motion is communicated to the shafts, either by means of cranks connected with the ends of balance beams, or with the piston heads of direct acting, or of oscillating, engines; and the position of the cranks towards one another is made such that the piston of one engine shall be able to exercise its full power, when the other is over its dead points. The wheels themselves consist of a series of radial arms, connected with one another by means of concentric rings (both the arms and circles being made of wrought iron), and upon the arms are fastened the floats, or the boards, whose revolution in the water produces the propulsive action. Very warm discussions have taken place with respect to the loss of power which necessarily attends the ordinary form of wheel, in which the floats are fixed radially to the wheel; and many ingenious contrivances have been proposed for the purpose of causing the floats to enter and to leave the water in a perpendicular direction. For vessels making short runs, the feathering paddles appear to produce satisfactory results; but it seems to be more than questionable whether the complication of the machinery, the additional weight of the wheels, and the consequent increase of power required to move them, do not more than compensate for the theoretical advantage gained by diminishing the slip observable in ordinary paddles. It is to be observed also, that numerous modifications of the form of the float boards have been introduced in order to diminish their inconveniences; and Field's wheel, in which the boards are divided into narrow slips, arranged in cycloidal curves, so as to enter the water at the same place in immediate succession, seems to be the best of its kind. Morgan's feathering wheel is one of the most successful of those engines; but after all the effective gain is very small, even with it. Generally speaking, the proportion of the useful effect of paddle-wheel engines to the power exerted is considered to be as 0·6 to 1·0 in the case of radial paddles; in the case of the feathering paddles it hardly exceeds 0·66 to 1·00, although at times it may rise to 0·833 to 1·000.

Whatever description of wheel be used, there is a point on its radii which describes a circle, known as the *rolling circle*, equal in its developed length to the distance actually traversed by the vessel during one stroke of the piston, and which serves to measure the ratio of the useful effect to the power exercised. It is important that the floats should be placed beyond this line, and in sea-going vessels exposed to cross, or rolling seas, the inner edge of the floats should even be kept at some considerable distance beyond it. There is still a remarkable discrepancy in the proportions assigned by different constructors to the various details of paddle-wheels, but the most generally received ones seem to be as follows. The diameter of the wheels is made equal to about from 4 to $4\frac{1}{2}$ times the length of the stroke, in ordinary condensing engines of vessels designed for deep-sea sailing; the breadth of the wheel is made from $\frac{1}{3}$ to $\frac{1}{2}$ of the diameter; the width of the floats is made about $\frac{1}{10}$ of the diameter of the wheel; and their distance apart is made about 3 feet to 3 feet 6 inches. Some constructors make the surface of their floats dependent upon the area of the midship section; and its proportion then varies between $\frac{1}{10}$ and $\frac{1}{17}$ of the latter, the best proportion seeming to be about $\frac{1}{14}$ of the said section. The best velocity to be given to the outer edges of the floats appears to be $\frac{2}{3}$ of that of the horizontal velocity of the vessel. Wheels of large diameter may be used on rivers without inconvenience; but in sea-going vessels a practical limit is placed to the increase of this dimension by the effect of the rolling of the ship, and the wheels are rarely made more than $\frac{1}{3}$ greater in diameter than the depth of the hold; but it must be repeated that at present all these rules are little better than empirical ones.

The screw has been occasionally used as a propeller for many years, but it was not until 1836, as above stated, that its use became sufficiently understood to allow of its being applied commercially. In that year Mr. Smith attracted attention seriously to the subject; but Captain Ericsson may fairly be considered to be entitled to the merit of having been the first to overcome the practical difficulties connected with the application of this description of propeller. At the present day it certainly seems that for all ordinary deep sea goods traffic, and, the experience of the Dutch also shows, for steam transport on canals and narrow rivers, this description of mechanism will ultimately supersede every other one used for the same purpose. For vessels of war the sheltered position of the screw, and of the engines, give that description of propeller an incomparable advantage over the exposed engines and wheels of paddle-boats.

The screw-propeller ordinarily used may be described as consisting of two or more arms (though at the present day it is very rarely that more than three arms are used), forming parts of screws of large diameter arranged upon a central shaft. This shaft is set in motion, either by means of gearing, or by direct-acting engines working upon the crank of the shaft; so that the screw, being set in revolution, advances in the water in the same manner that a wood screw would advance in that material. The width of the screw is usually made equal to about $\frac{1}{3}$ of the convolution of the thread in small screws, and to nearly $\frac{1}{2}$ of that dimension in larger ones, whilst the pitch is found to be of the most advantageous proportion when it bears to the diameter the ratios of 1·2 to 1 in large screws, and of 1·4 to 1 in small ones. All these dimensions, however, must vary with the peculiar form of the ship, and its resistance to motion in the water; and in Bourne's 'Catechism of the Steam Engine,' or, better still, in his 'Treatise on the Screw-Propeller,' the several conditions affecting the proportions of the screw are carefully discussed. The screw is usually placed in the dead wood of the ship, immediately before the rudder; and its efficiency materially depends on the depth of its immersion; as also upon the fineness of the stern of the vessel, perhaps almost as much as upon the entry, or upon the midship section. The velocity of revolution of the screw seems to range between 50 and 70 revolutions per minute, according to the shape of the vessel and to the dimensions of the screw itself. The size of the vessel to which the screw-propeller is applied seems to have a more favourable influence upon the useful effect produced, than is the case when the paddle-wheel is used; and for this reason also it is preferred for vessels of heavy burden and deep immersion.

In a well proportioned vessel, provided with a screw-propeller of the best form and mechanical conditions, there is very little slip or loss of the velocity attained by the screw itself; and it may be considered to range between 10 and 30 per cent. There is, however, a greater loss of the power developed by the engine in screw steamers than in paddle boats, in consequence of the friction and of the passive resistances to be overcome. This fact renders the use of the screw-propeller inadvisable on board vessels which trust mainly to their steam power; because it renders necessary the transport of a larger quantity of coal. Under ordinary circumstances it seems, however, that in cases where the paddle-wheels are kept at their normal immersion, and they are so proportioned as not to give an unnecessary amount of slip, they possess a slight mechanical advantage over the screw, for the purposes of propulsion. When the vessel is brought too deep in the water, or when the action of the sea disturbs the working conditions of the wheels, or when a side wind depresses one wheel whilst it leaves the other with an insufficient immersion, the advantage is in favour of the screw-propeller. Perhaps the screw interferes more with the steering properties of a ship than the paddle-wheels do; because when it ceases to be in motion its blades form a species of fan which intercepts the stream of water which would otherwise strike the rudder. The greater facility with which the screw-propeller can be adapted to the combination of steam and sail power more than compensates for this occasional inconvenience, which after all ceases to be felt when the ship is in the hands of an able seaman. The screw is least advantageous against head winds.

The majority of the screws used in the merchant service are made of cast iron, and they are cast solid. In the Royal Navy they are often made of brass; and on some occasions they are even forged of wrought iron. A very great number of modifications of their forms has been proposed, both for the purpose of obviating the loss of power occasioned by the slip, and of preventing the interference with the action of the rudder. Feathering screws, movable screws, converging blades, screws with a pitch increasing at their extremities, corrugated screws, Griffith's screw, with a circular boss upon the shaft, Beattie's screw, placed behind the rudder, lifting screws, and other contrivances, literally too numerous to mention, testify at least to the earnest character of the efforts made to remedy the inconveniences, real or imaginary, of a mechanical agent of such importance. Hitherto the results attained by these modifications have been far from satisfactory, and for ordinary traffic at least the screw is made upon nearly the same principles as it was in the earlier essays. It may perhaps be fair here to state that much of the merit of overcoming the difficulties attending the application of the screw-propeller was due to the late Mr. Brunel, on the occasion of the construction of the Great Britain; and he, in conjunction with Mr. Scott Russell, subsequently tried an experiment on a larger scale, in the application of both paddle and screw propulsion in the Great Eastern—with what commercial success remains yet to be seen.

(The best treatises in English upon the subject of steam propulsion in its different forms are Tredgold on the *Steam-Engine* and its Supplements; Hann and Genner on the *Steam-Engine;* Bourne, on the *Screw-Propeller*, and his *Treatise on the Steam-Engine.*)

PROPERTY is derived, probably through the French language, from the Latin word *Proprietas*, which is used by Gaius (ii. 89) as equivalent to ownership (*dominium*), and is opposed to *possessio*. [POSSESSION.] The etymology of the word *proprietas* (*proprius*) suggests the notion of a thing being a man's own, which general notion is contained in every definition of property. Blackstone (ii. 1) defines "the right of property" to be "that sole and despotic dominion which one man claims and exercises over the external things of the world, in total exclusion of the right of any other individual in the universe." A foreign writer defines ownership or property to be "the right to deal with a corporeal thing according to a man's pleasure, and to the exclusion of all other persons."

This definition excludes incorporeal things, which however are considered objects of property in our law, and were also considered as objects of property in the Roman law, under the general name of *jura*, or *jura in re;* they were considered as detached parts of ownership, and so opposed to *dominium*, a word which represented the totality of the rights of ownership. (Savigny, 'Das Recht des Besitzes,' 5th ed., p. 166.) This definition also describes property as consisting in a right, by which word right is meant "a *legal* power to operate on a thing, by which it is essentially distinguished from the mere possession of the thing, or the physical power to operate upon it. Consequently such a right is not established by the possession of the thing; and it is not lost, when the possession of the thing is lost. Such a right can also be enforced by him who possesses the right by an *actio in rem* against every person who possesses the thing, or disputes his right to it." (Mackeldey, 'Lehrbuch des heutigen Röm. Rechts,' ii., pp. 1–36.) This definition, which is characterised by a precision and accuracy which are altogether wanting in that of Blackstone, is here adopted. By property, then, is here understood only that which the positive law of a country recognises as property, and for the protection or recovery of which it gives a remedy by legal forms against every person who invades the property, or has the possession of it.

Austin observes ('An Outline of a Course of Lectures on General Jurisprudence') that "dominion, property, or ownership is a name liable to objection. For, first, it may import that the right in question is a right of unmeasured duration, as well as indicate the indefinite extent of the purposes to which the entitled person may turn the subject. Secondly, it often signifies property, with the meaning wherein property is distinguished from the right of possession. [POSSESSION.] Thirdly, dominion, as taken with one of its significations, is exactly co-extensive with *jus in rem*, and applies to every right that is not *jus in personam*." The first sense of the word property is expounded by determining, as hereafter explained, the quantity and quality of an estate as understood in English law. As to the second, possession is of itself no right, but a bare fact, and its relation to rights *in rem* is the same as the physical to the legal power to operate on a thing. The doctrine of possession is therefore distinct from and should precede the doctrine of property. [POSSESSION.] The third sense of property has reference to the legal modes of obtaining the possession of a thing in which a man can prove that he has property and a present right to possess.

A complete view of property, as recognised by any given system of law, would embrace the following heads, which it would be necessary to exhaust, in order that the view should be complete. It would embrace an enumeration of all the kinds or classes of things which are objects of property: the exposition of the greatest amount of power over such things as are objects of property, which a man can legally exercise—and connected with this, the different parts or portions into which the totality of the right of property may be divided, or conceived to be divided: the modes in which property is legally transferred from one person to another—that is, acquired and lost: the capacity of particular classes of persons to acquire and transfer property as above understood; or, to take the other view of this division, an enumeration of persons who labour under legal incapacities as to the acquisition and loss of property.

The following general outline of property is adapted to the English system of Law; it may be filled up by references to other articles in this work, or to treatises:—

1. The kinds or classes of things which are objects of property.

The general division is into Things Real and Things Personal, the incidents to which are so different in the system of English law that they must be separately considered.

Things Real are comprehended under the terms of Lands, Tenements, and Hereditaments. The word hereditaments is the most comprehensive of these terms, because it comprehends every thing which may be an object of inheritance, both things real and also some personal things, such as heirlooms, which are objects of inheritance.

Hereditaments are divided into Things Corporeal and Incorporeal. A Corporeal Hereditament is land, in the legal sense of the term. An Incorporeal Hereditament is defined by Blackstone to be "a right issuing out of a thing corporate (corporeal), whether real or personal, or concerning or annexed to, or exercisable within the same." Perhaps the definition is not quite exact, and it would not be easy to make an exact definition. The Things Incorporeal of the English law correspond in their general character to the *res incorporales* of the Roman law, one distinguishing character of which is that they are incapable of tradition or delivery (Gaius, ii. 28): the *res corporales* of the Roman law are things which are capable of tradition, whether moveable, as a horse, or immoveable, as a house. The incorporeal hereditaments enumerated by Blackstone are, advowsons, tithes, commons, ways, offices, dignities, franchises, corodies or pensions, annuities, and rents.

2. The greatest amount of power over such things as are objects of property which a man can legally exercise.

To this head belongs the English doctrine of Tenure, or the various ways in which land is said to be *held*. Though this was a much more important part of English law than it now is, it is still of importance; for tenure always exists wherever there is the relation of landlord and tenant. As all land in the kingdom is held mediately or immediately of the crown, it follows that a man cannot have a property in land which shall not be subject to this right of the crown. He cannot operate upon his property in land in any way so as to destroy this right; and consequently the utmost amount of property in land which a man can have is limited. The interest which a man can have in any land, tenement, or hereditament, is called an Estate; and this word comprises the greatest amount of power and enjoyment, both as to time and manner, which a man can legally have over and in any of the three things just enumerated, as well as the smallest legal amount of such power and enjoyment: it also comprises, under the notion of time, the determination of the period when his power and enjoyment shall commence, as well as when they shall cease. Lands, tenements, and hereditaments then being objects of property, a man may either have the most complete property in such things which is legally allowed, or he may have the least property in them which the law allows; and both this complete and this limited property is expressed by the word estate. An estate in a thing is property in a thing, and property in a thing is legally considered to be capable of division into defineable parts, called estates, each of which estates has its defineable legal incidents. With reference to an estate, the time during which the right of enjoyment continues is usually expressed by the term quantity of estate. The manner in which the enjoyment is to be exercised during this time is often expressed by the term quality of estate:

thus a man may enjoy an estate solely or in joint-tenancy; his enjoyment may be co-extensive with the largest amount of legal enjoyment of any estate, or it may be limited by the contemporaneous rights of others in or to the property in which he has an estate; that is, he may have the legal enjoyment for a determinate time, subject to various limitations and abridgments of the fullest enjoyment of property. The time when the enjoyment of the estate shall commence is also considered a part of its quality; and the time of enjoyment commencing is either present—that is, contemporaneous with the acquisition of the estate—or future. It may not be useless to remark, that here and elsewhere, where the word estate is used in its technical sense, it does not mean the thing enjoyed, but the quantity and quality of enjoyment of the thing.

Independent of the quality and quantity of an estate, there is another modification of property which requires notice. A person may have the estate both as to quantity and quality in the sense above explained, either with or without the right to the beneficial enjoyment. The person who has merely the estate in quantity and quality, has the bare legal estate. He who has not the right to the estate in quantity and quality, as above explained, but merely to the enjoyment of such estate, while the other has not, is said to have the equitable estate. The term quality of estate might be used to express this equitable interest; but inasmuch as we want a word to express the manner and mode of enjoying an estate as distinct from the time of enjoyment, and as quality is the word used to express that manner and mode, it must not be used in a different sense. The explanation of the nature of an equitable as distinguished from a legal estate belongs to Uses and Trusts.

It has been said that this distinction between legal and beneficial or equitable property is peculiar to the English law. (Lord Mansfield, 1 'T. R.,' 759, n.) But these two kinds of property existed in the Roman law, and the theory of the division of ownership or property into *quiritarian*, or legal, and *bonitarian*, beneficial, or equitable, was fully developed. Its origin in the Roman law is not certain; but it is a probable conjecture that its origin so far resembled the origin of the like division in English law, that it was due to the attempt to get rid of the difficulties attending the alienation of property by the old legal forms. "There is," says Gaius (ii. 40), "among other nations (*peregrini*) only one kind of ownership or property (*dominium*), so that a man is either owner or not; and it was the same in the old Roman law, for a man was either owner *ex jure quiritium*, or he was not. But ownership was afterwards divided, so that one man may now be owner of a thing *ex jure quiritium*, and another may have the same thing *in bonis*. For if, in the case of a *res mancipi*, I do not transfer it to you by *mancipatio*, or *in jure cessio*, but only deliver it, the thing indeed will become yours beneficially (*in bonis*), but it will remain mine legally (*ex jure quiritium*), till you have acquired the property by usucapion; for as soon as the time of usucapion is completed, from that time it begins to be yours in full ownership (*pleno jure*); that is, the thing begins to be yours both *in bonis* and *in jure*, just as if it had been transferred by *mancipatio* or in *jure cessio*." This passage seems to suggest a conjecture as to the origin of the distinction between legal and equitable property which was of so much importance in Roman law. The distinction between the two kinds of ownership or property was as clearly marked as in our system, though it was not applied to all the purposes to which this divided or double ownership is applied in our system.

3. The modes in which property is legally transferred from one person to another.

Property may either be acquired in a single thing, or in several things of the same kind at one time; or it may be acquired in a great variety of different kinds of things at the same time, which pass to the new owner, not as individual things, but as the component parts of a whole property. The Roman law designated the former mode of acquisition by the term *acquisitio rerum singularum;* and the latter by the term *acquisitio per universitatem.* Though the two modes of acquisition exist in our law, there are no names for them by which they are placed in opposition to one another. The case of *acquisitio per universitatem*, or of universal succession, occurs when a man is made a bankrupt or insolvent, and an assignee or assignees are appointed [BANKRUPT; INSOLVENT], in which cases the whole of a man's property, real and personal, as well as his rights and obligations generally, become the legal property of the assignee or assignees, and is applicable and must be applied according to the rules of law in the cases of bankruptcy and insolvency. With respect to personal property, universal succession occurs when a man by his last will appoints an executor; and an administrator with the will annexed, or without the will annexed when there is none, thereby acquires the whole personal property of the intestate. Both the heir and devisee also, in a sense take by universal succession.

As to both singular and universal succession, the modes of acquisition of estates in things real are reducible to two general heads—descent and purchase. "Descent, or hereditary succession, is the title whereby a man on the death of his ancestor acquires his estate by right of representation as his heir at law" (Blackstone); and an estate so acquired is commonly called an estate of inheritance.

Purchase, which is corrupted from the Latin word *perquisitio*, is defined by Littleton (i. 12) to be "the possession of lands or tenements that a man hath by his deed or agreement, unto which possession he cometh not by title of descent from any of his ancestors, or of his cousins (*consanguinei*), but by his own deed." Purchase, as thus defined, comprehends all the modes of acquiring property by deed or agreement, and not by descent; but it is not a complete description of purchase, as now understood, for it omits the mode of acquisition by will or testament, which, however, when Littleton wrote, was of comparatively small importance, as the power of devising lands did not then exist, except by the custom of particular places. Blackstone makes the following enumeration of the modes of purchase: Escheat, Occupancy, Forfeiture, and Alienation. As to escheat, there is some difficulty in the classification, as the title appears to be partly by descent and partly by purchase.

The head of alienation comprehends every form by which a man transfers property to another: it comprehends, therefore, both alienations made by a person during his life, and the disposition of his property by his last will and testament. The disposition of property by will has this peculiarity about it, that though the instrument must be completed in legal form during the lifetime of the giver, the persons to whom the property is given do not thereby obtain the property; they only obtain it by the death of the giver, who by that event becomes incapable of giving, but whose continuing intention to give is testified by the continuing existence of the instrument of gift.

The particular modes of alienation by deed are to a certain extent determined by the estate which the alienor possesses, and the estate or estates which he intends to transfer. The forms of alienation are noticed under their various heads.

4. The legal capacity for the acquisition of estates in lands, tenements, and hereditaments, is most briefly and conveniently shown by the enumeration of the classes of persons who labour under legal incapacity; and in like manner, as to the alienation or loss of estates, it is most conveniently shown by enumerating the persons who, owing to mental incapacity, infancy, or other causes, labour under legal incapacity to transfer or lose estates. This division comprehends so much of the status of aliens, infants, lunatics, and married women, as relates to the acquisition or loss of estates.

Personal property is not sufficiently described by the term "moveables," for certain estates in land are personal property, and are comprehended under the term chattels real. Terms for years are an example of chattels real; and they pass together with the rest of a man's personal estate to the executor, the universal successor. Chattels personal are all other personal property, and are said by Blackstone "to be properly and strictly speaking things *moveable*, which may be annexed to or attendant on the person of the owner, and carried about with him from one part of the world to another. Such are animals, household stuff, money, jewels, coin, garments, and everything else that can properly be put in motion, and transferred from place to place." Personal property as thus defined corresponds to the *mobilia* or *res mobiles* of the Roman law; but this is a very inadequate description of personal property as recognised by the English law. And herein we first perceive the greater certainty and distinctness of the law relating to real property compared with the law relating to chattels; the things which can be the objects of real property are defineable, as well as the estates that can be had in them; the things that can be the objects of personal property are hardly determinable, and the estates, or more properly the interests, which a man may have in them, are perhaps also less determinate. As examples of objects of personal property, which in no way come within Blackstone's description, we may instance patent-rights, which are things incorporeal, though not hereditaments, and are the objects of property.

A quantity of stock in the public funds is not money, though often talked of as such, but still it is property. Even debts due to a testator or intestate are considered as property with respect to probate and letters of administration; still they are not expressed by the term goods and chattels in the letters of administration, but by the term "credits," for as debts are not the property of a man to whom they are due, so they cannot become property because he happens to die. Things can be assigned by the person who has a claim to them, though they may be things which cannot be called his property: a chose in action is an instance of this. Blackstone observes: "the money due on a bond is a chose in action: for a property in the debt vests at the time of forfeiture mentioned in the obligation, but there is no possession till recovered by course of law." He had just before spoken of the nature of property in action being such that a man "hath not the occupation, but merely a bare right to occupy the thing in question.' From this it appears that he treats a debt due to a man as a property belonging to him, whereas the debt due merely gives a right of action to recover a determinate sum of money, or a sum which is less than some determinate sum. In this instance, says Blackstone, "the property or right of action depends upon an express contract or obligation to pay a stated sum." Here he uses property and right of action as synonymous, which is incorrect; for property implies a determinate thing, and a right of action may be either for a determinate thing or to compel a person to do some determinate act. The thing claimed is properly enough called a "thing in action," but the action is not to have a thing, but that the defendant shall do a certain act. Blackstone observes, in a note, that the same idea and the same denomination of property prevailed in the civil law, but this is a mistake. In the first passage ('Dig.' 41, tit. 1, s. 52), to which he refers in support of his statement, it is clear that a corporeal definite thing is spoken of, which the commentator could hardly have doubted about, if he had given in his note the whole of the passage instead of a part of it. The passage is this: "a thing is a man's *in bonis*, whenever he can defend his possession of it by a plea (*exceptio*), or recover it when lost by an *actio*." This *actio* would be in rem: the declaration of the plaintiff would affirm that the thing was his. In the other passage quoted by Blackstone ('Dig.' 50, tit. 16, s. 49), things which consist "in *actionibus, petitionibus, persecutionibus*" are included among the things *in bonis*; but the things in action so spoken of are things which a man has not, as contrasted with things which a man has, in his possession, and these are things corporeal, things determinate. Besides, even if we should admit that the Roman law treated a debt as a thing *in bonis*, it did not treat it as property, for a thing *in bonis* was not property in the sense in which Blackstone is here using property. Further, when a Roman claimed a debt, his declaration was that something ought to be given to him or done for his benefit by the defendant; and this "giving" always meant giving something which did *not* belong to the plaintiff, for it was a principle of Roman law that you could not give to a man what already belonged to him. But the Roman law had a precision in these matters of which the commentator had not the slightest idea.

From these remarks it will appear, first, that there is a difficulty in classifying the things that are objects of personal property; second, that things, as choses in action, are not property, and yet they can be transferred (in equity) as if they were property. Accordingly it happens that it is sometimes difficult to say whether a particular thing is an assignable thing or not, whether in its nature it is capable of any transfer.

Property in chattels may, like property in things real, vary as to quantity and quality of interest, though things personal are not capable of such extended and various modifications, analogous to estates, as things real are. As to quantity, that is, duration, a man may have the use of a personal thing for life, and another may have the absolute property in it after his death. As to quality, persons may own a thing personal as joint tenants and as tenants in common. There is an equitable property in chattels as well as in things real. Money, for instance, is often paid to a trustee, in order that he may give the interest of it to one person for life, and after his death pay the money to another. The trustee, so long as he holds the money, has the legal property in the money, and in the thing in which the money is invested. A legatee has only an equitable interest, even in a specific legacy, after his testator's will is proved, until the executor gives the thing to him, or in some clear way admits his right to it.

The modes of acquiring and losing personal property are reduced by Blackstone to the following principal modes:—Occupancy; prerogative, whereby a right accrues to the crown or the crown's grantee; forfeiture, which is a punishment for a crime or misdemeanour; custom, as heriots, &c.; succession, by which term Blackstone understands the capacity of a corporation aggregate to take what their predecessors had; marriage, by which the husband acquires the chattels of the wife, and the right of suing for her choses in action, and a peculiar kind of interest in her chattels real; judgment; gift or grant; contract; bankruptcy and insolvency, so far as relates to chattels; testament; administration. The enumeration taken from Blackstone is not here offered as one that is complete or altogether unexceptionable. Under contract Blackstone includes sale, as to which it may be observed that the formalities required by the law for the transfer of ownership in things personal are few; but the difficult questions which arise as to the transfer of property in personal things are probably much more numerous than in the case of estates in things real.

Under contract he also comprehends bailment, by which "a special qualified property is transferred from the bailor to the bailee together with the possession." This qualified property, as it is called, gives the bailee a right of action against all persons who injure or take away the chattels; and Blackstone, as usual, finds a reason for this right of action. This right of action is however really founded on the right of possession, and it is just the same right of action that a man has who finds a thing, against any person, except the owner, who injures or takes away the thing. This right, when understood, is in all respects consistent with sound principles; and there is no objection to calling it a right founded on a qualified property, when the term qualified property is rightly understood. Under contract, he also includes hiring and borrowing, and these also are contracts which, he says, may transfer a qualified property to the hirer or borrower. The same remarks apply to this kind of property as to that acquired by bailment. There is, however, a case in which a man must acquire an absolute property by borrowing, as in the case of the Roman mutuum, when the thing borrowed is a thing which consists "*pondere, numero*, or *mensurâ*," as, for instance, so many pounds of butter. The distinctions of the Roman law between hiring, "*locatio et conductio*," lending, "*mutuum*," "*commodatum*," and "*depositum*," are founded on unchangeable principles, and are expounded in that system with a clearness which, in this respect, ours perhaps does not admit.

The incapacities of persons as to acquiring personal property are fewer than those as to real property; and the incapacities to transfer and lose are also fewer. But a complete enumeration of the classes of persons who labour under either of these incapacities, and the particular incapacities of each of such classes, would probably be more difficult than a like enumeration as to estates in real property.

PROPERTY-TAX. [TAXATION.]

PROPHECY (*προφητεία*, a foretelling, or the power of foretelling) in its popular acceptation is a foretelling, or a thing foretold. In classical Greek, *prophêtes* (*προφήτης*) corresponds with the Latin *vates*, which indeed may be regarded as the same word without the preposition. In the Old Testament, the Hebrew *nevuah* (to bubble forth) implies something of inspiration; but in Numbers xii. 6, there is a difference made between Moses, with whom God spake "mouth to mouth," and other prophets, with whom he spoke "in a dream." In Exodus vii. 1, Aaron is directed to be the "prophet" of Moses, or, as is explained in Exodus iv. 16, his interpreter, or to "be to him as a mouth." St. Paul uses *prophetes* (Tit. i. 12), which is rendered "prophet" in the authorised version, but "poet" by Tyndale; and probably Epimenides is meant. S. Chrysostom ('Hom. in 1 Cor.') says that *prophetes* is the same as *herméneutes* (*ἑρμηνευτὴς*), an interpreter; and Festus says that the chief priests of the temples and interpreters of the oracles were by the ancients called prophets.

Under ORACLE it is observed that there were current in ancient Greece numerous so-called prophecies, but they were dark and ambiguous. This is not the case with the prophecies recorded in the Bible. Some of these were extant in books written long before the events took place to which they refer, such as the prophecy concerning Abraham's posterity, their extraordinary increase, their sufferings in Egypt four hundred years, their sojourning in the wilderness, and their possessing at length the land of Canaan. The numerous prophecies in the Old Testament pertaining to the Messiah, with their accomplishment recorded in the New Testament, and the prophecies of Jesus and his Apostles, are so familiar to the minds of all, that they need not be specified. The prophecies of the Old and New Testament, which have been long fulfilled, afford altogether an amount of evidence which, if really understood, it seems impossible to resist, in proof of the Bible being a revelation from God.

The prophecies of the Old and New Testament are understood by all believers in scriptural prophecy to be predictions of future events pronounced by persons who, on the occasion of delivering such predictions, were directed and governed by the Deity. The first thing to establish in the examination of these prophecies is the genuineness of the books in which they are contained. The question is, whether the prophecies in the form in which we have them, were delivered before the events to which it is alleged that they refer. This is purely a matter of historical criticism, and in no respect differs in the manner of carrying on the investigation, from an inquiry of a like kind as to any other book. The next inquiry is to compare the alleged prophecy with the events of which it is alleged that it was a prediction. This, though apparently the easier part of the inquiry, is one wherein much difference of opinion may exist. Some of the prophecies are clear and precise in their terms; and when the former part of the inquiry has had a satisfactory result, no unprejudiced person can doubt that the prophecies do refer to certain definite events. Some of the prophecies are in their terms vague and general; and others refer to events which, it is admitted, have not yet been accomplished. So far as it is admitted that any prophecy has not been accomplished, so far it must be admitted that prophecy fails in being substantiated by the only evidence that can establish its truth. It is then on those events which all believers allege to be events accomplished, in conformity to genuine predictions, that the proof of prophecy depends. The method of investigation is that which has been already mentioned, and every man should come to it with an unprejudiced mind.

PROPIONAMIDE. [PROPIONYL.]

PROPIONE. [PROPIONYL.]

PROPIONIC ACID. [PROPIONYL.]

PROPIONIC ALDEHYDE. [PROPIONYL.]

PROPIONITRYL. [ETHYL, *cyanide of.*]

PROPIONYL ($C_6H_5O_2$). The radical assumed to exist in a number of organic compounds collectively known as the propionic group, and of which the chief member is propionic acid. The name is derived from *πρῶτος*, *first*, and *πίων*, *fat*, because propionic acid is the first in the series of fatty acids, which separates as an oily layer when liberated in aqueous solutions of its salts.

Hydride of propionyl ($C_6H_5O_2$, H). *Metacetic* or *propionic aldehyde.*—This is one of the products of the oxidation of albumen, fibrin, or casein, by a mixture of sulphuric acid with either binoxide of manganese, or bichromate of potash. It is isolated from other matters that are obtained at the same time, by fractional distillation.

Hydride of propionyl is a limpid liquid, of agreeable ethereal odour, sp. gr. 0·79; boiling point between 130° and 150° Fahr., and vapour density 2·111. It slowly acidifies when exposed to the air.

Hydride of pentachloropropionyl ($C_6Cl_5O_2$, H), or *propionic chloral*, is one of the products of the action of hydrochloric acid and binoxide of manganese upon starch. It is an oily liquid, crystallising in rhombic tables on exposing to a temperature of 32° Fahr.

Propione ($C_{10}H_{10}O_2$), or the *ethylide of propionyl* ($C_6H_5O_2$, C_4H_5).—The product of the destructive distillation of propionate of baryta. It is a colourless or slightly yellow-coloured liquid of agreeable odour, insoluble in water, but soluble in alcohol or ether. Its boiling point is 212° Fahr. It is inflammable, burning with a pale blue flame. Nitric acid converts it into propionic acid.

Propionic anhydride, or *anhydrous propionic acid* $\left(\begin{matrix}C_6H_5O_3\\C_6H_5O_3\end{matrix}\right\}\Big)$ is a colourless liquid formed on distilling a mixture of two equivalents of oxychloride of phosphorus, and six of dried propionate of soda. It has a disagreeable odour, is not soluble in water, and boils at 329° Fahr.

Propionic acid $\left(\begin{matrix}C_6H_5O_3\\HO\end{matrix}\right\}\Big)$. *Metacetic acid*, or *metacetonic acid.*—This acid is one of the products of the oxidation of oleic acid; it is also produced by the action of strong caustic potash upon sugar, starch, gum, or mannite, and by the action of ferments upon glycerin. The most convenient method of preparing it is to add cyanide of ethyl drop by drop to a concentrated alcoholic solution of potash contained in a retort. The reaction that then takes place is thus expressed:—

$$\underbrace{C_4H_5, C_2N}_{\text{Cyanide of ethyl.}} + \underbrace{2HO}_{\text{Water.}} + \underbrace{KO, HO}_{\text{Potash.}} = \underbrace{KO, C_6H_5O_3}_{\text{Propionate of potash.}} + \underbrace{NH_3}_{\text{Ammonia.}}$$

On distilling the residue with sulphuric acid, or with syrupy phosphoric acid, pure propionic acid passes over.

Propionic acid crystallises in plates. On the application of a gentle heat it fuses, and at 284° Fahr. boils. It is very sour, and has a pungent odour, somewhat like a mixture of butyric and acrylic acids. Water takes up a large quantity of it, excess floating like an oil upon the saturated solution.

Propionates, or the salts of propionic acid, are mostly crystalline, and soluble in water. They are all monometallic, and easily decomposed by strong acids. *Propionate of potash* is very deliquescent. *Propionate of soda* crystallises with difficulty; it forms a *double salt* with acetate of soda, crystallising in needles, and containing ($C_4H_3NaO_4$, $C_6H_5NaO_4 + 9$ Aq). *Propionate of baryta* ($C_6H_5BaO_4$) crystallises in prisms. *Propionate of lime* forms silky fibres. *Propionate of copper* ($C_6H_5CuO_4$ + Aq.) crystallises in small oblique prisms: it is very soluble in alcohol, but only slightly so in water. *Propionate of lead* is uncrystallisable. *Propionate of silver* ($C_6H_5Ag.O_4$) crystallises in tufts of needles; it forms a *double salt* with acetate of silver, containing ($C_4H_3AgO_4, C_6H_5AgO_4$). *Propionate of ethyl; propionic ether; metacetic ether* ($C_6H_5(C_4H_5)O_4$) is obtained on distilling propionate of soda with alcohol and sulphuric acid. It is lighter than water, boils at 213°·8 Fahr., and has an odour resembling rum.

Nitropropionic acid ($C_6H_4(NO_4)O_4$), *nitrometacetic acid*, is a heavy yellow oil slightly soluble in water, but very soluble in alcohol. It possesses an aromatic odour and a sweet taste, and is inflammable, burning with a reddish flame. It forms crystalline monometallic salts with bases. For the method of preparing it, see BUTYRIC ACID, *butyrone.*

Propionamide, or *nitride of propionyl* $\left(\begin{matrix}C_6H_5O_2\\H\\H\end{matrix}\right\}N\Big)$ results from the action of ammonia on propionate of ethyl.

PROPORTION. There must be in the mind of every person, antecedently to all mathematical instruction, a perfect conception of proportion, though not perhaps of the manner of measuring magnitudes with a view to express their proportions by means of numbers. All who can trace the resemblance of a drawing to the original, or have the least notion of the use of a map, are in possession of the fundamental notions on which a theory of proportion can be founded. The term RATIO is that under which the first part of the subject should be treated, and the article cited will contain matter preliminary to the present one. It will be sufficient for our present purpose to state that the ratio or relative magnitude of two magnitudes is to be measured by the number of times or parts of times which one is contained in the other, whenever the two are commensurable; and we shall now confine ourselves to the purely mathematical treatment of the theory of proportion, and shall avoid, as much as the nature of the subject will admit, all discussion of the notion of ratio considered as a magnitude.

We cannot well explain the nature of the difficulty which occurs in the theory of proportion, without a prior reference, first, to the purely arithmetical treatment of the subject, and secondly, to the *practical* sufficiency of this method which is the necessary consequence of our physical constitution.

If all magnitudes of the same kind were necessarily commensurable, that is, if any one among them being taken as a unit, the rest were all expressible by multiples, aliquot parts or submultiples, and multiples of aliquot parts, of the unit chosen, no difficulty would arise in making the subject of proportion purely arithmetical. For let a and b represent the units, parts of units, or both, in two magnitudes of the same kind (as two lines); any sufficient demonstration of the rule for the division of one fraction by another will show that a contains b precisely a number of times and parts of times. If then we say that a is to b in the same proportion as c to d, we mean that a contains b precisely such times and parts of times as c contains d: that is, we assert the equation

$$\frac{a}{b} = \frac{c}{d};$$

the mathematical treatment of which is so easy, that no one who can solve a simple equation can be stopped for a moment by the difficulty of any consequence of it. The following proposition, which may be proved generally, contains all the consequences which are most useful. Let a, b, c, and d be (in the arithmetical sense) proportional: take any two functions of a and b, which are homogeneous and of the same dimension (such as $ab+b^2$ and a^2-b^2). Take corresponding functions of c and d (which are $cd+d^2$ and c^2-d^2); then the four numbers so obtained are also proportional (that is, $ab+b^2$ contains a^2-b^2 as many times and parts of times as $cd+d^2$ contains c^2-d^2).

In measuring magnitudes of which the numerical representatives are afterwards to be submitted to calculation, it necessarily follows, from the imperfections of our senses, that some imperceptible amount of magnitude must always be neglected or added; so that, for example, that which we call a line of 3 inches long means something between 2·9 and 3·1, or 2·99 and 3·01, or 2·999 and 3·001, according to the degree of accuracy of the measurement. All magnitudes therefore are practically commensurable; for suppose, in the case of weights for example, that a grain is taken as the unit, and that the ten-thousandth part of a unit is considered as of no consequence; then by taking every weight only to the nearest ten-thousandth of a grain, they may every one be expressed arithmetically with a conventional degree of precision, which for every purpose of application will do as well as though it were perfectly accurate.

The discovery of INCOMMENSURABLE magnitudes, one of the most striking triumphs of reason over the imperfection of the senses, was made at a very early period; since the demonstration of their existence, the classification (to a certain extent) of their species [IRRATIONAL QUANTITIES], and the means of overcoming the difficulties which they present, appear in the writings of Euclid. A moment's consideration will show that a property of numbers, a relation of figure in geometry, a general law of nature, may be inferred from induction with a degree of probability which will amount to moral certainty, both as to the exactness and universality of the property, relation, or law. But the existence of incommensurable magnitudes can never be made certain except by absolute deduction: no attempt at measurement, a *minimum visibile* existing, could show the non-existence of any common measure, however small. Suppose for instance that, having provided means of measurement which can always be depended on to show the *thousandth* of an inch, but nothing less, a person should accurately (as the word is commonly used) lay down squares of one, two, &c., inches in the side, with a view to render the existence of a common measure to the side and diagonal exceedingly improbable by experiment. If not before, he would be baffled by the square whose side is 2378 inches, the diagonal of which could not by his measures be distinguished from 3363 inches, from which it differs only by about the *five-thousandth* part of an inch. And let any greater degree of exactness be attained in the means of measurement, short of positive accuracy, a reasoner on the subject could still predict a square which should defeat the attainment of the object sought.

The mere existence of incommensurables, to say nothing of their frequent occurrence, and the impossibility of avoiding them, renders the arithmetical theory of proportion inexact in its very definition. If we would say, for instance, that the diagonal of a larger square is to its side as the diagonal of a smaller square is to its side, we enunciate a proposition the meaning of which is unsettled. For if we mean to assert that the larger diagonal contains the larger side as many times or fractions of times as the smaller diagonal contains the smaller, it is answered, by those who wish for precise notions, that neither diagonal contains its side any exact number of times or parts of times. If we should say that the larger diagonal lies between 1·414213 and 1·414214 times the larger side, and that the smaller diagonal also lies between 1·414213 and 1·414214 times the smaller side, and if we should show this to be true, we certainly show that we could produce lines very nearly equal to the diagonals, which are, under the arithmetical definition, proportional to the sides; and that this might be done without altering either diagonal by so much as the millionth part of the side. And the ten-millionth, hundred-millionth, or any aliquot part of the side, however small, might be substituted for the millionth, without detriment to our power of showing the truth of the proposition. If we use the means by which this process may be carried on *ad infinitum*, we may perhaps be said to have established the truth of the proposition that the diagonals of squares are as their sides. But if we in any manner stop short of this, we destroy the rigorous character of geometry, and produce a system of mathematics which, like a common table of logarithms, is true to a certain number of places of decimals, and not farther. It is obvious that such a system of mathematics, like the table with which we have compared it, is sufficient for the purposes of practical application; nor have we the least quarrel with those who, desiring an instrument only, are content with one which is sharp enough for their purpose. We only complain of them when they assert and teach others that their tool has an edge keen enough to separate the minutest truth from the minutest falsehood; whereas, on examining it with a powerful microscope, we find the so-called sharp edge capable of being magnified into a plane of any dimensions, though it may appear a sharp edge to the unassisted senses.

The imperfection of the definite arithmetical definition of proportion is universally admitted, while the complexity of the rigorous definition by which Euclid supplied its place is almost as universally felt to be a grievance. Many attempts have been made to avoid the trouble without incurring the reproach of inaccuracy. One or two of these we shall notice.

Legendre, in his otherwise excellent work on geometry, refers the student to works on arithmetic for the theory of proportion; and, having stated that when A is to B as C to D, it is known that A × D = B × C, adds (twelfth edition, page 61), "This is certainly true for numbers; it is true also for any magnitudes, provided they can be expressed, or that we imagine them expressed by numbers, and this we may always suppose." A system of geometry which tells the learner in so many words that he may always suppose that which is not true, needs no further comment, even though Legendre were its author. It is true that in subsequent parts of the work we find demonstrations adapted to the case of incommensurable quantities, but they want that most important element of a proposition involving proportions, namely, a definition of what the term means; these demonstrations turn upon the theorem that when four quantities are proportional, the first is greater than, equal to, or less than the second, according as the third is greater than, equal to, or less than the fourth; but it has not been previously stated what the author means by four quantities being proportional. In the English translation of the preceding work, a preliminary chapter is added on proportion, in which the definition given as to incommensurable magnitudes amounts to the following:—when A and B are incommensurable, and also C and D, the four are said to be proportional when A′ and C′ can be found, as near as we please to A and C, and which, being commensurable with B and D, are proportional to them, in the arithmetical sense of the term. This is a sufficient definition; but it really amounts to that of Euclid (as do all sufficient definitions which we have seen), and is not so easily used.

M. Lacroix ('Elémens de Géométrie,' p. 5) makes the approximate finding of a common measure stand in place of an exact process, and, fairly stating that the error of the process may be made too small to be visible, rests the exactness of his geometry on its not being sensibly erroneous.

The author of the 'Elements of Geometry,' in the 'Library of Useful Knowledge,' states the proportion of incommensurable magnitudes to consist in "their ratios admitting of being approximately represented by the same numbers, *to how great an extent soever* the degree of approximation may be carried." In virtue of the words in italics, this definition may be considered as being, when properly used, capable of forming the basis of an exact theory; and that it is properly used in the work cited we fully admit, since its first application is to the establishment of the definition of Euclid. The only objection we should make to the work in question is that its expressions (page 48) would lead the student to imply that commensurability is the general rule, and incommensurability the exception; an extended theory is given, because magnitudes are not always commensurable. Now it is important the student should know, and should always bear in mind, that of two magnitudes of the same kind taken at hazard, or one being given and the other deduced by a geometrical construction, it is very much more likely that the two should be incommensurable than that they should be commensurable. So that the apparently cumbrous theory of proportion is not introduced to meet a few cases which sometimes occur, but to prevent the majority of instances from being treated incorrectly.

The definition* of proportional quantities given by Euclid is as follows:—"Magnitudes are said to have the same ratio to one another, the first to the second, and the third to the fourth, when equimultiples of the first and third, and equimultiples of the second and fourth, whatever the multiplications may be, yield a multiple of the first, greater than, equal to, or less than, that of the second, according as the multiple of the third is greater than, equal to, or less than, that of the fourth." That is, if A, B, C, and D be the four magnitudes, and *m* and *n* any two whole numbers whatsoever, *m* A must be greater than, equal to, or less than *n* B, according as *m* C is greater than, equal to, or less than *n* D. Otherwise thus: whatever whole numbers *m* and *n* may be, A must exceed, equal, or fall short of *n*-*m*ths of B, according as C exceeds, equals, or falls short of *n*-*m*ths of D. A person practised in algebra would comprehend the definition most easily when stated thus: $m\text{A} - n\text{B}$ must have the same sign as $m\text{C} - n\text{D}$, for all whole values of *m* and *n*.

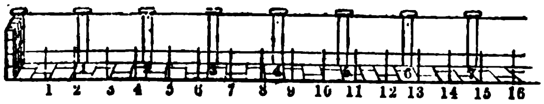
This definition equally applies whether A and B be commensurable or incommensurable, since no attempt is made to measure B by an aliquot part of A. The two questions which must be asked, and satisfactorily answered, previously to its reception, are as follows:—

1. What right had Euclid, or any one else, to expect that the preceding most prolix and unwieldy statement should be received by the beginner as the definition of a relation the perception of which is one of the most common acts of his mind, since it is performed on every occasion where similarity or dissimilarity of figure is looked for or presents itself?

2. If the preceding question should be clearly answered, how can the definition of proportion ever be used; or how is it possible to compare every one of the infinite number of multiples of A with every one of the multiples of B?

To the first question we reply, that not only is the test proposed by Euclid tolerably simple, when more closely examined, but that it is, or might be made to appear, an easy and natural consequence of those fundamental perceptions with which it may at first seem difficult to compare it. To elucidate this, suppose the following case:—

There is a straight colonnade composed of columns at equal distances from each other, the first being distant from a bounding wall by a length equal to the distance between any two successive columns. In front of the colonnade let there be a row of railings* equidistant from each other, the first being at the same distance from the wall at which the railings are from each other. Let the columns be numbered from the wall, and also the railings; remember also that it is not supposed that there goes any exact number of railings to the interval of two columns, but that the interval of the columns may be to the interval of the railings in any ratio, commensurable or incommensurable.



If we may suppose this construction carried on to any extent, it is easily shown that a spectator, by mere inspection, without measurement, may compare the column-distance (C) with the railing-distance (R), to any degree of accuracy. For example, since the tenth railing falls between the fourth and fifth columns, it follows that 10 R is greater than 4 C and less than 5 C, or that R lies between $\frac{4}{10}$ of C and $\frac{5}{10}$ of C. To get a more accurate notion, he may examine the 10,000th railing: if it fall between the 4674th and 4675th columns, it follows that 10,000 R lies between 4674 C and 4675 C, or R lies between $\frac{4674}{10000}$ and $\frac{4675}{10000}$ of C. There is no limit to the degree of accuracy thus obtainable; and it can also be shown that the ratio of C and R is determined when the order of distribution of the railings among the columns is assigned *ad infinitum*; or, which is the same thing, when the position of *any* given railing can be found, as to the numbers of the columns between which it lies. Any alteration, however small, in the place of the first railing, must at last affect the order of distribution. Suppose, for instance, that the first railing is moved farther from the wall by one part in a thousand of the distance between the columns, the second railing must then be pushed forward twice as much, the third three times as much, and so on: those after the thousandth are pushed forward more than a thousand times as much,—that is, by more than the interval between the columns,—or the order with respect to the columns is disarranged.

Let it now be proposed to make a model of the preceding construction, in which *c* shall be the distance between the columns, and *r* that between the railings. It needs no definition of proportion, nor anything more than the conception which we have of that term prior to definition (and with which we must show the agreement of any definition we may adopt), to assure us that C must be to R in the same proportion as *c* to *r*, if the model be truly formed. Nor is it drawing too largely on that conception of proportion if we assert that the distribution of the railings among the columns in the model must be everywhere the same as in the original: for example, that the model would be *out of proportion* if its 56th railing fell between the 18th and 19th columns, while the 56th railing of the original fell between the 17th and 18th columns. Here, then, the question as to the dependence of Euclid's definition upon common notions is settled; for the obvious relation between the construction and its model which has just been described contains the collection of conditions, the fulfilment of which, according to Euclid, constitutes proportion. According to Euclid, whenever *m* C exceeds, equals, or falls short of *n* R, then *m c* must exceed, equal, or fall short of *n r*: by the most obvious property of the preceding constructions, according as the *m*th column comes after, opposite to, or before the *n*th railing, in the original, th *m*th column must come after, opposite to, or before the *n*th railing, in the correct model.

That the test proposed by Euclid is necessary, appears from the preceding; and also that it is sufficient. For, admitting that, to a given original, with a given column-distance in the model, there is one correct model railing-distance (which must therefore be the one which distributes the railings among the columns as in the original), we have seen that any other railing-distance, however slightly different, would at last give a different distribution: that is, the correct distance, and the correct distance only, satisfies all the conditions required by Euclid's definition.

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* The Greek of Euclid's definition is very short, and can only be intelligibly rendered into English by circumlocution. *Ἐν τῷ αὐτῷ λόγῳ μεγέθη λέγεται εἶναι, πρῶτον πρὸς δεύτερον καὶ τρίτον πρὸς τέταρτον, ὅταν τὰ τοῦ πρώτου καὶ τρίτου ἰσάκις πολλαπλάσια τῶν τοῦ δευτέρου καὶ τετάρτου ἰσάκις πολλαπλασίων, καθ' ὁποιονοῦν πολλαπλασιασμὸν, ἑκατέρου ἢ ἅμα ἐλλείπῃ, ἢ ἅμα ἴσα ᾖ, ἢ ἅμα ὑπερέχῃ ληφθέντα κατάλληλα.*

* By the terms column and railing we mean throughout to designate vertical lines which are the axes of the columns or railings.

Let us now, by the *distribution* of one set of magnitudes among those of another set, agree to mean the placing of the first magnitudes among those of the second set, the latter having been previously arranged in ascending order of magnitude. Thus, in the following instance, we distribute the multiples of 3 among those of 8, the latter being in Roman numerals:—

3 6 viii 9 12 15 xvi 18 21 xxiv 27 30 xxxii &c.
24

This use of the word distribution having been well learnt, the following way of stating the definition will be easier than that of Euclid:—"Four magnitudes—A and B of one kind, and C and D of the same or the same other kind—are proportional when all the multiples of A are distributed among the multiples of B in the same intervals as the corresponding multiples of C among those of D." Or, whatever numbers *m* and *n* may be, if *m* A lie between *n* B and (*n* + 1) B, *m* C lies between *n* D and (*n* + 1) D.

If the preceding test be always satisfied from and after any given multiples of A and C, it must be true before those multiples. For instance, let the test be always satisfied from and after 100 A and 100 C; and let 5 A and 5 C be instances for examination, falling before 100 A and 100 C. Take some multiple of 5 which will exceed 100, say 50 times, and let it be found on examination that 250 A lies between 678 B and 679 B; then 250 C lies between 678 D and 679 D. Divide these by 50, and it follows that 5 A lies between $13\frac{28}{50}$ B and $13\frac{29}{50}$ B, and still more between 13 B and 14 B. Similarly, 5 C lies between $13\frac{28}{50}$ D and $13\frac{29}{50}$ D, and still more between 13 D and 14 D. Or 5 A lies in the same interval among the multiples of B in which 5 C lies among the multiples of D; and the same demonstration applies to any other instance.

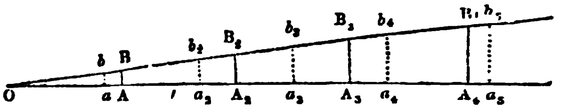
Again, the test is also satisfied if the multiples of any multiple (*m*) of A are distributed among the multiples of any multiple (*n*) of B in the same manner as the multiples of *m* C among the multiples of *n* D: for instance, if the multiples of 3 A be distributed among those of 5 B in the same manner as the multiples of 3 C among those of 5 D. Let 11 A and 11 C be given for examination; take any multiple of 3 greater than 5, say 3 × 3, or 9, and examine 11 (9 A) and 11 (9 C), or 33 (3 A) and 33 (3 C). Let 33 (3 A) lie between 27 (5 B) and 28 (5 B); then by hypothesis 33 (3 C) lies between 27 (5 D) and 28 (5 D). Divide all by 9, and we find that 11 A lies between 15 B and $15\frac{5}{9}$ B, while 11 C lies between 15 D and $15\frac{5}{9}$ D. Hence 11 A lies between 15 B and 16 B, while 11 C lies in the same interval among the multiples of D; and in the same manner any other instance may be proved.

The principles of the fifth book of Euclid are by many supposed to be inevitably connected with the apparatus of straight lines drawn parallel to one another, by which Euclid represents his magnitudes and their multiples. This is not the case; and the simple expression of magnitudes by large letters, and of numerical multipliers by small ones, will very much facilitate the demonstrations, without altering anything but mere modes of expression.

The next point to be considered is the infinite character of the definition of proportion; four magnitudes are not to be called proportional, until it is shown that every multiple of A falls in the same interval among the multiples of B, in which the same multiple of C is found among the multiples of D. So that this definition is a negative one, like that of parallel lines, which may be thus stated: two lines are parallel when every point of one of them, however far produced, is on one side of the other. We might expect then to find that the test of *disproportion* is simple and positive, and an examination of the illustration already produced will confirm this.

Suppose that the distribution of the railings among the columns should be found to agree in the model and the original as far as the millionth railing. This proves, as we have seen, only that the railing-distance of the model does not err by the millionth part of the corresponding column-distance; for if it did err so much, the multiplication of the error a million-fold would have placed the millionth railing (if none before it) wrong by at least one interval. It is then obvious that no examination of individual cases, however extensive, will enable an observer of the construction and its model to affirm the proportion or deny disproportion: all that it can do is to enable him to fix limits (which he may make as small as he pleases) to the disproportion, if any. But a single instance may enable him to deny proportion or affirm disproportion, and also to state which way the disproportion lies. Let the 19th railing in the original fall beyond the 11th column, while the 19th railing of the (so-called) model does not come up to the 11th column. It follows from this one instance, that the railing-distance of the model is too small relatively to the column-distance, or that the column-distance is too great relatively to the railing-distance; that is, the proportion of *r* to *c* is less than that of R to C, or the proportion of *c* to *r* is greater than that of C to R. Similarly, with respect to two straight lines, no examination of pairs of points, one in each, will enable the examiner to affirm their parallelism or deny their intersection; while, at the same time, the examination of one pair of points may enable him to affirm intersection or deny parallelism. Hence it appears that, obvious as the notion of proportion may be, it is more easy, in a mathematical point of view, to define disproportion, and to make proportion consist in the absence of all disproportion. Similarly, obvious as is the notion of parallelism, and the connection of the non-intersection of two straight lines with that of their always keeping the same distance with each other, it is more easy to define this relation by the absence of all intersection than by any of its positive properties.

The negative character of the definition of parallels does not prevent it from being very easily proved that such lines exist; and an examination of the first or last propositions of the sixth book of Euclid will show that the existence of proportional quantities is as easily established on the definition given as on any other. To take an instance, however, in which nothing but lines shall be the objects of consideration, we shall here prove, in a different manner, the second proposition of Euclid's sixth book, or one to the same effect.



Let O A B be a triangle, to one side of which *ab* is drawn parallel, and in O A produced set off AA_2, A_2A_3, &c., equal to O A, and aa_2, a_2a_3, &c., equal to O *a*. Through every one of the points so obtained draw parallels to A B, meeting O B produced in *b*, b_2, B_2, &c. Then it is easily proved that bb_2, b_2b_3, &c., are severally equal to O *b*, and BB_2, B_2B_3, &c., to O B. Consequently a distribution of the multiples of O A among those of O *a* is made on one line, and of O B among those of O *b* on the other. The examination of this distribution in all its extent (which is impossible, and hence the apparent difficulty of using the definition) is rendered unnecessary by the known property of parallel lines. For since A_3 lies between a_3 and a_4, B_3 must lie between b_3 and b_4; for if not, the line A_3B_3 would cut either a_3b_3 or a_4b_4. Hence, without inquiring where A_m *does* fall, we know that if it fall between a_n and a_{n+1}, B_m must fall between b_n and b_{n+1}: or if *m* × O A fall in magnitude between *n* × O *a* and (*n* + 1) × O *a*, then *m* × O B must fall between *n* × O *b* and (*n* + 1) × O *b*. Thus it is established that O A is to O *a* as O B to O *b*.

The propositions of the fifth book become very simple when the definition is fully elucidated, and symbolic expression is substituted for the words at length of Euclid. They will be found thus treated in Playfair's or Lardner's editions of Euclid, and in the 'Connection of Number and Magnitude' (London, 1836).

When quantities are commensurable, a multiple of one may be found which is exactly equal to a multiple of the other: thus if A = $3\frac{4}{13}$ B, 13 A = 43 B. In this case the arithmetical definition of proportion is sufficient, and the other may be shown to follow from it. Let A = $3\frac{4}{13}$ B, and C = $3\frac{4}{13}$ D, so that, arithmetically speaking, A is to B as C to D. Let *m* A lie between *n* B and (*n* + 1) B, or ($3\frac{4}{13}$ *m*) × B lies between *n* B and (*n* + 1) B. Then the number or fraction $3\frac{4}{13}$ *m* must lie between *n* and *n* + 1; whence ($3\frac{4}{13}$ *m*) D lies between *n* D and (*n* + 1) D, or *m* C lies between *n* D and (*n* + 1) D.

It is however perfectly allowable to leave out of sight the possible case in which a multiple of A is exactly equal to a multiple of B; since if the test be true in all other cases, it is therefore true in this. For, if possible, let 4 A = 7 B, and 4 C be (say) greater than 7 D. Then *m* (4 C) exceeds *m* (7 D) by *m* times this difference, which may be made as great as we please, or 4 *m* C, and multiples succeeding it, may be made to fall in an interval as many intervals removed from that of 7 *m* D and (7 *m* + 1) D as we please. But 4 *m* A is equal to 7 *m* B, whence (4 *m* + 1) A, &c., must fall among the multiples of B in intervals of given nearness * to the interval of 7 *m* B and (7 *m* + 1) B. Consequently the multiples of A following 4 *m* A cannot always fall among the multiples of B in the same intervals as the same multiples of C among those of D; and the rest of the test cannot be true, unless 4 C = 7 D; that is, if the rest of the test be true, then 4 C = 7 D.

The following question will enable the reader to see for himself how far he is able to apply the method of Euclid:—Returning to the illustration, suppose that the columns, instead of being mathematical lines, are of a given thickness, and that the columns in the model are of a proportionate thickness; let it also be supposed that when a railing is projected upon the column, there are no means of determining on which side of the axis of the column it falls. It is to be shown that if the distribution be according to the definition as to every railing which is not so projected, and about which there is therefore no doubt, it must also be true as to every case in which the doubt exists.

The advantages of the study of proportion in the manner laid down by Euclid, or some other equivalent in extent and strictness, are precisely the advantages of accuracy over inaccuracy, and of real demonstration over a false and slovenly appearance of it, which, though a close resemblance, is therefore all the more dangerous. And it must be remembered what we mean by demonstration, namely, the process of obtaining a conclusion by sound logic from premises known to be true. If the prolixity of Euclid's method could be avoided by an assumption, we should not object, provided the assumption were both true and easily seen to be true. For instance, if the theory of PARALLELS could be established without its axiom by means of a hundred

* We leave the reader to put this demonstration into a more exact form.

long and intricate propositions, we should agree with those who would refuse to place those propositions before beginners, on the ground that unimpeachable demonstration is already given, namely, an assumption which those who would rather dispense with it do not deny to be both true and easy (or capable of being made easy), and logic which is uncontested and incontestable. But the vice of the system which is substituted for that of Euclid, consists in the entrance of an assumption which is *not* true; for to reason upon all magnitudes as if they were commensurable, and to assert conclusions derived from such reasonings, is to assume that all magnitudes are commensurable, which is not true. The method of Lacroix, as above explained, is sound as far as it goes: he asserts that the propositions of geometry are sensibly true, or if false, imperceptibly false, and this he proves. But he makes geometry cease to be an exact science. That of Legendre, on the other hand, though it proves no more than that of Lacroix, professes to prove more: it treats geometry as an exact science, while it avowedly states that an assumption may be made which is demonstrably incorrect.

We do not deny that a mind well versed in the doctrine of limits would have a process of its own, by which it would rigorise the method of Lacroix, arguing as follows:—The same means which show the propositions of geometry to have no error perceptible to our senses, would also show them to have no error perceptible to any imperfect senses, however near to perfection they might be; and that error which is less than any assignable error, must be no error at all. All this, when properly extended, we might admit; but how are we to suppose, in the student who has just left the fourth book of Euclid, a perception of the truths of the doctrine of limits, the notorious want of which creates the difficulties of the differential calculus? Sound teaching makes a true theory of proportion one, out of many previous helps, to the attainment of the differential calculus: but the inversion of the process not only adds difficulty to the latter, by intercepting proper illustration, but introduces falsehood into the former; and such teaching is the most vicious of all vicious circles, because it propagates its kind.

The mathematical writers of this country have, taken altogether, shown a superiority in exactness of demonstration over those of any other of modern times, and the deep and early root which the sound principles of Euclid have taken has been mainly the cause of this. If those principles be abandoned, that superiority will cease to exist; but this of itself would be of little consequence; not so the loss of a large amount of formation of accurate habits, which would certainly follow the substitution of a gross and (so called) practical instrument of calculation for an exact and liberal science.

Those to whom the mathematical sciences are taught as aids to the power of distinguishing truth from falsehood, logic from fallacy, the exact consequence from all incorrect inference, very many times exceed in number those who only wish for an instrument to be used in the study of physics and the arts of life. If then practical mathematics mean those mathematics which best answer the purpose of the great majority of learners, the more they are rigorous the more they are practical. But the enticing word *practical* has been otherwise appropriated; and "exact enough for practical purposes" is the phrase applied to many a result of which the practical use belongs to the astronomer, mechanician, surveyor, engineer, or computer. To such a meaning of the word practical there is no objection as opposed to liberal or disciplinatory, when it is *knowledge* or *science* which is spoken of; but as applied to *art*, practical is opposed to unpractical, which cannot be carried into practice, or useless, for that which cannot be practised is useless in art. But those who would consider the use of knowledge in steadying the mind and making it a judge between the true and the false, and a safe guide to the methods of finding truth, must beware, in mathematics, how they allow the notions which art attaches to the word practical any influence over their method of studying science. For want of such a caution many have missed all comprehension of the higher branches even of the art to which they aspired, to say nothing of the loss of that science to which it should seem they did not mean to aspire.

PROPORTION, in Music, is either *Harmonical* or *Rhythmical*.

Harmonical Proportion is when, of three numbers representing the relations of sounds, the first has the same proportion to the third as the difference between the first and second has to the difference between the second and third; as in the numbers 6, 8, 12; where

$$6 : 12 : : 8-6 : 12-8;$$

that is to say, $6 : 12 : : 2 : 4.$

When four numbers are in Harmonical Proportion, then the first has the same proportion to the fourth as the difference between the first and second has to the difference between the third and fourth; as in the numbers 6, 8, 12, 18; where

$$6 : 18 : : 8-6 : 18-12;$$

that is to say, $6 : 18 : : 2 : 6.$

The proportions of the sounds of the diatonic scale [Diatonic] are as follows:—

The Key-note	1 : 1
2nd	9 : 8
3rd (major)	5 : 4
4th	4 : 3
5th	3 : 2
6th	5 : 3
7th	15 : 8
8th, or octave	2 : 1

[Scale; Acoustics.]

Rhythmical Proportion is the proportion, in relation to time or measure, between the notes representing duration. Thus, the semibreve to the minim is 2 : 1; the semibreve to the crotchet, 4 : 1; the minim to the semiquaver, 8 : 1; &c. That is, the semibreve is twice as long in time as the minim; four times as long as the crotchet, &c.

PROPORTIONAL COMPASSES. [Compasses.]

PROPORTIONAL LOGARITHMS, also called logistic logarithms. [Tables.] Suppose it frequently required to calculate the fourth term of a proportion of which the first term is one given quantity, say A: that is, required a fourth proportional to A, p, and q. Common logarithmic calculation here requires three inspections of the table, one addition, and one subtraction. But if A be always the same thing, a new table may be framed, which shall only require two inspections and one addition, as follows:—Opposite to p in the table, write log A —log p instead of log p, and call the former the proportional logarithm of p, which must be considered as the abbreviation of "logarithm of p proper to be used in proportions of which the first term is A." The rule then is;—to find a fourth proportional to A, p, and q, add the proportional log of p to that of q, and the sum is the proportional logarithm of the answer. For log A — log p, and log A — log q, added together, give

$$\log \text{A} - \log \frac{pq}{\text{A}};$$

which is, by definition, the proportional logarithm of $pq \div \text{A}$, the answer required.

In tables made to be used with the old Nautical Almanac, in which the moon's motion was given for every three hours, A was made $= 3^h = 10800^s$; and p and q were given in the table, not in seconds, but reduced to hours, minutes, and seconds. Thus the question—

$$3^h : 1^h\,23^m\,18^s : : 14^m\,13^s : x,$$

could be answered, and x found, by two inspections and an addition. But the convenience of this table lay much more in the arrangement into hours, minutes, and seconds, than in the nature of the substitute for the logarithm: and since a similar arrangement is now made to accompany common tables of logarithms, it may be doubted whether the day of logistic logarithms be not past.

PROPORTIONAL PARTS, a name given in logarithmic and other tables to small tables which are annexed to the differences of the tabular number, and which consist merely in setting down the several tenths of the differences or the nearest whole numbers to them. Thus, in the case of 953, the table of proportional parts is as follows:—

953	
1	95
2	191
3	286
4	381
5	477
6	572
7	667
8	762
9	858

Thus, 286 is the whole number nearest to 3-tenths of 953; from which we infer that 29 is the whole number nearest to 3-hundredths of 953. If then we would have ·74 of 953 to the nearest whole number, we take

7 tenths	667
4 hundredths	38
	705

or 705 is the nearest whole number required, subject to the possibility of an error of a unit, which is of no consequence in the matters for which such tables are used. This is the process required in logarithmic interpolation, when tables of seven decimal places are used. Makers of tables now begin to give complete multiples. with one figure separated, as by a comma.

PROPORTIONS, DEFINITE. [Atomic Theory.]

PROPOSITION. [Organon.]

PROPYL (C_3H_7), sometimes called *trityl*—from τρίτος, *third*—is the third organic radical in the series $C_n H_{n+1}$. It is the assumed root of the members of the propylic, or tritylic, group of organic compounds. The following are the only members of the propylic group at present known.

Propylene (C_3H_6). *Tritylene.* This gas is one of the products of the decomposition of amylic alcohol on passing through a red hot porcelain tube. It is most readily prepared by distilling one part of iodopropylene with five of mercury and two of concentrated hydrochloric acid. It is evolved in a tolerably copious stream, one ounce of iodopropyl yielding more than 150 cubic inches of gas.

Propylene has a peculiar odour somewhat resembling olefiant gas, a sweetish suffocating taste, and a sp. gr. of 1·498. It is tolerably soluble in alcohol, but water absorbs only about one-eighth of its bulk. It may be liquified by great pressure.

Iodo-propylene, or *iodide of allyl* (C_6H_5, I) is formed on distilling a mixture of equal parts of iodide of phosphorus and syrupy glycerin. It is a colourless liquid of sp. gr. 1·789, of ethereal alliaceous odour, a sweet but irritating taste, insoluble in water, but soluble in alcohol or ether. It rapidly becomes brown on exposure to air.

Iodide of propylene (C_6H_6, I_2). At a slightly elevated temperature, iodine absorbs propylene and forms a colourless liquid of ethereal odour, and density 2·49. It rapidly decomposes in contact with air.

Chlorides and *bromides of propylene*. Chlorine and bromine act upon propylene in much the same way as upon Ethylene, and the resulting compounds yield chlor- or brom-propylenes when treated with alcoholic potash. The following are the compounds referred to :—

Name.		Boiling point.	Density.
Chloride of propylene	C_6H_6, Cl_2	219·2	1·151
Chlor-propylene	C_6H_5Cl		
Chloride of chlor-propylene	C_6H_5Cl, Cl_2	338	1·347
Bichlor-propylene	$C_6H_4Cl_2$		
Chloride of bichlor-propylene	$C_6H_4Cl_2', Cl_2$	383 to 392	1·548
Trichlor-propylene	$C_6H_3Cl_3$		
Chloride of trichlor-propylene	$C_6H_3Cl_3, Cl_2$	428 to 437	
Quadrichlor-propylene	$C_6H_2Cl_4$		
Chloride of quadrichlor-propylene	$C_6H_2Cl_4, Cl_2$	464 to 473	1·731
Quintichlor-propylene	C_6HCl_5		
Chloride of quintichlor-propylene	C_6HCl_5, Cl_2	500	1·781
Sexchlor-propylene	C_6Cl_6		
Chloride of sexchlor-propylene	C_6Cl_6, Cl_2	536	1·860
Bromide of propylene	C_6H_6, Br_2	293	1·974
Bromo-propylene	C_6H_5Br	143·6	1·472
Bromide of bromo-propylene	C_6H_5Br, Br_2	377·6	2·336
Bibromo-propylene	$C_6H_4Br_2$	248	1·950
Bromide of bibrom-propylene	$C_6H_4Br_2, Br_2$	439	2·469
Tribrom-propylene	$C_6H_3Br_3$		
Bromide of tribrom-propylene	$C_6H_3Br_3, Br_2$	491	2·601

Hydrate of propyl, or *propylic alcohol* (C_6H_7O, HO), is contained, along with amylic alcohol, in the last portions of the distillate in the first rectification of spirits of wine. It is separated by fractional distillation. It is a limpid liquid, lighter than water, and of agreeable fruity odour. It is very soluble in water, and boils at about 205° Fahr.

Chloride of propyl (C_6H_7, Cl). Fuming hydrochloric acid slowly absorbs propylene at 212° Fahr.; on saturating the liquid with carbonate of soda, chloride of propyl is obtained. It is a liquid lighter than, and insoluble in, water; boils at 104° Fahr., and in odour, taste, and inflammability, much resembles chloride of ethyl.

Propyl-sulphuric acid (C_6H_7O, HO, S_2O_6) is formed on mixing propylic alcohol with sulphuric acid. Diluted with eight or ten times its bulk of water, saturated with carbonate of potash, evaporated to dryness, the residue dissolved in boiling absolute alcohol and set aside, furnishes acicular crystals of *propyl-sulphate of potash* (C_6H_7O, KO, S_2O_6).

Propylamine $\left(\left.\begin{matrix}C_6H_7\\ H\\ H\end{matrix}\right\}N\right)$. *Tritylamine. Metacetamine. Onylamine.* This body is formed on acting upon iodopropylene with ammonia; it may be extracted by caustic potash. It is an oily body very soluble in water, of ammoniacal odour and alkaline reaction. It boils between 122° and 140° Fahr. It combines with acids to form salts: the *chloroplatinate* contains ($C_6H_9N, HCl, PtCl_2$).

Arsenide of propyl. One of the products of the distillation of a mixture of arsenious acid and dry butyrate of lime appears to be arsenide of propyl, but it has not been thoroughly examined. It does not ignite spontaneously.

PROPYLÆUM (*προπύλαιον*: the great entrance to the Acropolis of Athens was called *προπύλαια*, in the plural number; Thucydides, ii. 13), signifying literally a fore-portal or one detached from and placed in advance of the building to which it gave access, is used as a distinctive term for the structures through which was the entrance into the enclosure surrounding some of the Grecian temples. Unlike the vast truncated pyramidal masses or moles that enclosed the forecourt of Egyptian temples, on the entrance side, leaving only a lofty square-headed portal for access, thereby screening the main edifice and colonnades within the court, and giving the exterior the aspect of a fortress,—the propylæa of the Greeks were detached structures placed in advance of the sacred edifice itself, so as to mark very conspicuously the approach to it through the outer enclosure or boundary. They seem to have been intended in some degree to prefigure the temple to which they conducted; their general appearance in front being almost identically the same as that of the frontispiece-façade or pediment end of a prostyle temple.

The general arrangement and character of a Greek propylæum may be described as similar to those of an amphiprostyle temple [Temple], shorter however on its sides than the width in front, and without any *cella*, yet not entirely open to both fronts, but divided by an inner wall across it from side to side, into two portions, the outer one of which, answering to the *pronaos* of a temple, was larger than the other; so that the whole may be more briefly, if not more intelligibly explained, by comparing the plan to the *pronaos* and *opisthodomus* of an amphiprostyle temple, put together without any intervening cella, being separated only by the wall above mentioned, in which were as many open doorways as there were intercolumns in front.

Such was the disposition of the propylæa both of the Parthenon at Athens and of the temple at Eleusis, the only two examples of such structures known to us, and the latter now so only by the drawings of it in the unedited antiquities of Athens: there were, indeed, as we learn from Pausanias (ii. 3) propylæa at Corinth, but of their architectural design we know nothing. The Athenian structure stands on the west side of the Acropolis, but is not on the same axis or line as the temple. This propylæum, which was begun by the architect Mnesicles in the 4th year of the 85th olympiad, and completed in five years, is of the Doric order, and hexastyle on both fronts; and the outer or western one was greatly extended by two flanking wings projecting forward at right angles, so as to enclose the platform to which an ascent of steps led up from below, and above which the portico and the two lesser colonnades forming the sides of the wings were raised upon three other steps. Thus the platform (78 feet from north to south, by 40 east and west) became an elevated open fore-court, presenting a principal portico in front crowned by a pediment, and two colonnades, which being considerably lower (their columns 19 feet, the others 28½ feet high) gave greater importance to the former; and a degree of scenic effect—combination, contrast, and variety—was produced, very unusual in Grecian architecture.

One of the most remarkable circumstances which served to distinguish the Propylæa from a portico is that in the outer division there were two rows of inner columns placed not parallel with, but at right angles to the columns in front, and in a line with the two middle ones, thereby dividing the plan internally into three compartments, the centre one narrower than the other two, and forming an avenue to the principal doorway, which was the largest and loftiest of the five openings in the transverse wall, and the two end ones the smallest. These inner columns, too, instead of being of the same order as the exterior, were Ionic,—a very remarkable peculiarity, inasmuch as it evidences an intermingling of styles almost unknown to Grecian architecture. The licence—so to call it—was, however, fully justified by the circumstances of the case, because columns of lesser diameter than the external ones were required, and also of such height as to reach the architrave soffits of the internal ceiling, which are in a line with the top of the architrave of the external order.

The Eleusis propylæum resembled that of the Acropolis in nearly all particulars, except that it had no wings attached to it. Like the Athenian one, it was of the Doric order, hexastyle on both fronts, and had six Ionic columns within, similarly in two rows.

As modern structures partaking of the ancient Greek propylæum character, may be mentioned Cagnola's Porta Ticinense at Milan, and the London terminus of the London and North-Western Railway, in Euston Square, which, though only a distyle in antis in both fronts, is a fine example of Grecian Doric upon a scale of extraordinary magnitude. Both the modern examples, however, differ from the ancient ones in being entirely open, without any internal transverse wall; and the Italian one has, moreover, a large open arch on each side, forming a passage through it in that direction.

PROPYLAMINE. [Organic Bases; Propyl.]

PROPYLENE. [Propyl.]

PROROGATION. [Parliament.]

PROSE comprehends any species of composition which is not written in metre. Modern writers have differed much respecting what constitutes the distinction between prose and poetry. Some writers maintain that the whole class of compositions, which have pleasure for their *main* object, ought to be regarded as poetry; but Whately, on the other hand, contends that metre is the essence of poetry, and consequently defines poetry as "elegant and decorated language, in metre, expressing such and such thoughts," and good prose-composition "such and such thoughts expressed in good language" ('Rhetoric.') [Poetry.]

PROSELYTE (*προσήλυτος*, connected with *προσέρχομαι*, *to come to*), a new comer. This word is not found in classical Greek, but occurs many times in the Septuagint, and a few times in the New Testament. It answers to the Hebrew, גֵּר, a stranger. "Proselytes," says Suidas, "are they who have come out of the Gentiles, and live according to the divine laws." The word is applied almost exclusively to persons converted to the religion of the Jews. It is now usually applied to converts from one religion or religious sect to another, but is occasionally used in reference to political theories.

PROSERPINA. [Persephone.]

PROSERPINE. [Asteroids.]

PROSODY (προσῳδία) is derived from a Greek word, which has exactly the same meaning as the Latin *accentus*, and was used by the Greeks in the same sense. (Quintil., 'Inst. Orator,' i. 5; Aulus Gellius, xii. 6.) Most modern writers however make a distinction between prosody and accent, understanding by the former what is usually called *quantity*, that is, the duration of a sound. Thus it is said that the principle of Greek and Roman versification is *quantity*, while that of the poetry of the modern European languages depends on *accents*. It is not however improbable that what the ancients meant by *quantity* was not very different from what we call *accent*. [ACCENT.] The subject is well treated in an able article in the fourth volume of the 'Journal of Education,' published under the superintendence of the Society for the Diffusion of Useful Knowledge, 1832.

PROTECTION ACTS. The object of these statutes is to enable a debtor in insolvent circumstances to avert or forestall the impending danger of imprisonment; for any person not a trader within the Bankrupt Acts, or who, being a trader, owes less than 300*l.*, whether in prison or not, may apply in London to the Insolvent Court, in the country to the County Courts, for protection from process. A *schedule* of debts, and of the names of his creditors, must accompany the petition; which must set forth an account of his whole estate and liabilities, and be verified by affidavit.

On the petition being filed, the court makes an *interim order*, which protects the petitioner from all civil process until his *examination*, but he may still be arrested under a judge's order, to hold him to bail. If in prison, the order effects the petitioner's discharge. The presentation of the petition vests all the petitioner's effects in the registrar, who, as *official assignee*, proceeds to possess himself of all that can be obtained without suit. Notice of the petition is given to the creditors, and inserted in the 'Gazette' and local newspapers, a public sitting of the court being at the same time appointed for the first examination of the petitioner. If it appear that the allegations in the petition and the matters in the schedule are true, and that the debts have not been contracted fraudulently or improperly, and do not arise from any of the acts of misconduct enumerated in the statutes, a day is fixed on which a *final order* shall be made, unless cause be shown to the contrary. If made, its effect is to permanently protect the petitioner from all process, in respect of the debts due, at the time of filing the petition, to the creditors named in the schedule. On the other hand, if cause is shown, the court may adjourn the consideration of the final order *sine die*, or dismiss the petition.

At any time *after* the final order, the assignees of the estate may claim property since acquired by the insolvent, which claim may be summarily enforced by the order of the court. So that under the Protection Acts, as in the case of an insolvency, the *future* as well as *present* property of the debtor may be applied in payment of his debts. In this consists the great distinction between the relief afforded by the bankrupt laws to a *trader*, and that obtainable by an *insolvent debtor*, or a petitioner under the Protection Acts.

(Blackstone's 'Commentaries,' Mr. Kerr's edition, vol. ii. p. 516.)

PROTECTOR. [SETTLEMENT.]

PROTEIN, a substance obtained by Mulder from albumen, casein, horn, and animal and vegetable fibrin. When any one of these is dissolved in a solution of potash, and the filtered solution is mixed with a slight excess of acid, a copious grayish-white, flocculent precipitate is formed, and a slight smell of hydrosulphuric acid is perceived. This white substance is *protein*, so called from its occupying the first or most important place in relation to the albuminous principles.

Its properties are:—While moist the white flocculi are diaphanous, but by drying they become yellowish, hard and brittle. It possesses neither smell nor taste, attracts moisture rapidly from the air, and loses water at 212°. It is insoluble in water, alcohol, ether and essential oils. By long continued boiling in water it undergoes some change of properties, and is rendered soluble.

Acetic and phosphoric acids, whatever may be their state of concentration, dissolve it; hydrochloric acid also dissolves protein, and acquires an indigo tint. When heated the solution blackens. With concentrated sulphuric acid it produces a jelly which contracts in water, and which, after being washed with water and alcohol, though it does not redden litmus-paper, contains 8·34 per cent. of sulphuric acid. Mulder calls this compound *Sulphoproteic acid.* When protein is boiled in dilute sulphuric acid, it acquires a purple tint.

Protein is precipitated from its acid solutions by the ferro and ferridcyanide of potassium, by tannin, and by neutralisation with an alkali. When strongly heated, protein is decomposed with the production of ammonia and a charcoal which burns with difficulty, but leaves no residue.

Protein consists entirely of carbon, hydrogen, nitrogen, and oxygen; and it will be observed, that whether obtained from albumen (1), casein (2), horn (3), animal fibrin (4), or vegetable fibrin (5), the statements of its composition differ so slightly, as to show that it must be the same from whichsoever of the sources named it is procured.

	(1)	(2)	(3)	(4)	(5)
Carbon . .	55·30	55·16	55·408	55·44	54·99
Hydrogen . .	6·94	7·17	7·238	6·55	6·87
Nitrogen . .	16·02	15·86	15·593	16·65	15·66
Oxygen . .	21·84	21·81	21·761	21·36	22·48

These analyses may be represented by the formula $C_{144}H_{122}N_{14}O_{24}$, and consequently protein may be regarded as albumen in which two equivalents of sulphur are replaced by oxygen.

When protein, or the substances which yield it, are boiled in a concentrated solution of potash as long as ammonia is evolved, and the solution is afterwards neutralised by sulphuric acid, evaporated to dryness, and the residue treated with boiling alcohol, three products of the decomposition are dissolved, one of which, *erythroprotide*, separates in oily drops as the solution cools; *leucin* is deposited in small crystalline scales by spontaneous evaporation; whilst the mother water contains *protide* and formiate of ammonia in solution.

Binoxide, or *oxyprotein*, and tritoxide of protein are produced by the long continued action of boiling water upon fibrin in contact with air. They are the chief ingredients of the buffy coat of the blood in a state of inflammation, being produced at the expense of the fibrin.

PROTEST. [BILL OF EXCHANGE; NOTARY; LORDS, HOUSE OF.]

PROTESTANT, a general term comprehending all those who, professing Christianity, yet are not in the communion of the general church or confederacy of Christians of which the pope is the head and the city of Rome the centre or capital. There is great variety of opinion among persons thus separated, in points of faith, church order, and discipline, but this term covers and comprehends them all, leaving the varieties in opinion to be marks of specific differences only under the genus Protestant.

The term originated in Germany, and the occasion was this:—At the Diet at Spire, in 1526, decrees had been passed which were so far favourable to the progress of the Reformation that they went to forbid any peculiar exertions against it. The consequence was that the spirit of reformation gained strength, and spread itself more extensively in Germany. Then arose also commotions which were attributed to the reformed and to the spirit kindled by them. Both the pope and the emperor looked with increasing alarm on the aspect of affairs, and at another Diet, held at the same place in 1529, the emperor directed an imperial brief to the persons assembled, to the effect that he had forbidden all innovation, and proscribed the innovators in matters of religion, who had notwithstanding increased since the decrees of 1526, but that now, by virtue of the full powers inherent in him, he annulled those decrees as contrary to his intentions. The peremptory tone of these letters alarmed the persons present at the Diet; and particularly the elector of Saxony is reported to have said to his son, that no former emperor had used such language, and that he ought to be informed that their rights were more ancient than the elevation of his family.

This strong measure of the emperor had also the effect of uniting, at least on this point, the two great sections of German reformers, the Lutherans and the Sacramentarians, of whom Zuinglius was the head. However, the party opposed to the Reformation was the stronger, and the emperor's brief received the sanction of the Diet. Then it was that the reformers took the high ground of declaring that this was not a business of policy or temporal interests, with respect to which they were ready to submit to the will of the majority, but it affected the interests of conscience and futurity. On this and other grounds they founded a *protest*, which was delivered in on the 19th day of April, but refused by the Diet. A second protest, larger than the former, was presented on the succeeding day. The princes and the cities who favoured the Reformation joined in it, and thenceforth it became usual to call the reformers *Protestants*.

It is often found that a particular incident or occasion leads to the construction of a name for a religious party, which becomes extended, as in this instance, to parties who have no immediate connection with the particular incident, or interest in the question with which it is connected. The term Protestant, in fact, seems to have as much to do with the constitution of the Germanic confederacy as with the principles of the Reformation; and certainly, neither England nor Scotland had anything to do with the proceedings of the emperor or with the Diet of Spire. The Reformed Church might seem to designate the Church of England or the Church of Scotland more appropriately than the Protestant church. However, it must be owned, that few things are more difficult than to coin terms by which to designate a religious community which shall not be open to objection and cavil.

PROTRACTOR. Any instrument for laying down angles is so called, such as the graduated semicircle which is found in cases of instruments, the rectangular ruler with graduated edges, and various other more expensive contrivances. But the truth is that the easiest and safest protractor is a table of CHORDS, a scale of equal parts, and a pair of compasses: those who have not a sufficient table of chords should take the chord from a table of sines by the formula—

$$\text{chord of } x = \text{diameter} \times \text{sine of half } x.$$

Even the scale of chords laid down on the rulers, used in the usual manner, is a better protractor than the graduated semicircle, which is worthless, except for very rough work. A good table of chords carried to every minute under 180°, is, we believe, not yet published in this country.

PROVERB (from the Latin *proverbium*, that is, *pro-verbum*, in which respect the form of the word bears analogy to *prœludium*, and other words of the kind), a by-word, which meaning is also conveved by *adagium*, "adage," and the Greek *paroemia* (παροιμία). Of the many definitions which have been given of a proverb, the best appears to be the following by Synesius, a Christian writer of the early part of the 5th century, who quotes from a work of Aristotle, now lost: "A proverb is a remnant of the ancient philosophy preserved amidst very many destructions on account of its brevity and fitness for use." To collect and explain such portions of wisdom has engaged the attention of some of the most learned men. Aristotle, Theophrastus, Chrysippus, and others, according to Laertius, made collections of proverbs. With the works of Plutarch is printed ('Opera Moralia,' vol. v.) a collection of 131 proverbs, with explanations; and, though this collection has not been uniformly acknowledged as Plutarch's, there is good reason to believe it to be his genuine work. Zenobius or Zenodotus, a Sophist who lived at the beginning of the 2nd century, made an epitome of the proverbs of two older writers, Tarræus and Didymus, in number 552. Diogenianus lived about the same time as Zenobius, and made a collection of proverbs, amounting to 775. These two collections, together with 1400 proverbs out of Suidas, and an appendix of 353 from the Vatican Library, and a selection of proverbs in metre, were well edited by Andrew Schott, 4to, Antwerp, 1612. The adages of Erasmus, in number 4151, are too well known to require any description. They are presented in their most useful form in the Epitome of them published by the Elzivirs, 12mo, Amst., 1663. Many modern writers have published collections of proverbs from various languages. The name of our own countryman, John Ray, is familiar to all the lovers of natural history. In 1672 he published his collection of proverbs, which has been often reprinted. Modern languages contain a great number of proverbs, and it is remarkable how many can be traced to an ancient origin, and how many are the common property of nations civilised and barbarous, so as to seem almost universal. Again, the proverbs peculiar to a nation or country never fail to mark distinctly the character and condition of the people. There is a valuable collection of English proverbs, with lengthened explanations, by Ray, by Oswald Dykes, and by H. G. Bohn, which also contains a selection of foreign proverbs.

PROVERBS OF SOLOMON, one of the canonical books of the Old Testament. The Hebrew מָשָׁל, translated *proverb*, denotes a similitude, and is rendered in the Septuagint by παροιμία, but oftener by παραβολή.

This book has always been ascribed to Solomon, though he was not the author of all its contents. The thirtieth chapter is entitled "The words of Agur the son of Jakeh," and the thirty-first chapter, "The words of King Lemuel;" and it is not improbable that many of the proverbs in the preceding part of the book were in current use long before the time of Solomon. The portion from the tenth chapter to the end of the twenty-fourth, comprises what may more strictly be called the 'Proverbs of Solomon.' The first nine chapters form a kind of introduction, and the remaining chapters after the twenty-fourth may be regarded as an appendix to the whole.

The Book of Proverbs is classed by Bishop Lowth among the didactic poems of the Hebrews ('De Sacra Poesi Hebr.,' Præl. xxiv.) The attentive reader of the original will discover the utmost exactness in the choice and arrangement of words, and will be able with ease to carry out the principles laid down by Lowth relating to the structure of Hebrew metre.

The Proverbs of Solomon are all pre-eminently adapted to teach the lessons of prudence, morality, and religion. They are a precious treasury, from which men may be supplied with the best rules for the conduct of life. (Patrick *On the Proverbs of Solomon*; Horne's *Introduction*.)

PROVIDENCE is the superintending care with which God watches over his whole creation, and especially over the human race. It has been generally held, as a direct consequence of the existence of a God who has created all things, that he must also uphold by his constant care everything which he has created. This doctrine however has been denied by the ancient Epicureans and the modern Theists, who, while admitting that God created the universe, and impressed upon it the laws by which it is governed, have contended, that having done this, he has left those laws to work out their own results without his further interference. The arguments for a superintending providence are derived from the order of the material universe, which we find to be governed by ever-active principles, of which no other explanation can be given than that they are the results of the power of God in continued exercise; from the events which are recorded in history, and which are daily occurring, such as the punishment of guilty nations and individuals, the exaltation of the virtuous, the adaptation of great men to the exigencies of their times, not to mention other circumstances in the history of individuals, which might be considered of a more doubtful character; and lastly, from the unequivocal statements of Scripture. The whole sacred narrative is evidently intended to show how God's providence wrought for the accomplishment of his own designs. Moreover, individuals are mentioned, such as Pharaoh, Nebuchadnezzar, and Cyrus, whom God raised up expressly in order to use them as instruments to effect certain objects. Two books of the Old Testament, those of Job and Esther (we might perhaps add those of Ruth, Jonah, and even others), appear to have been written for the very purpose of confirming our faith in the providence of God; and numerous passages might be quoted which teach the care of God over the whole universe (Col. i. 17; Heb. i. 3; Rev. iv. 11), over all men, whether good or wicked (Job xxv. 3; Matt. v. 45; Acts xvii. 28; James i. 17), and especially over his own people (Matt. v. 25-34, &c.).

The providence of God has been divided by theologians into *immediate*, or that which he exerts without the intervention of second causes, and *mediate*, where ordinary means are employed; into *ordinary*, which relates to occurrences in the common course of nature, and *extraordinary*, where that course is departed from, as in the case of miracles; into *common*, of which the whole world is the object, and *special*, which regards the church; and into *universal*, which describes the care of God for his whole creation, and *particular*, which is exercised for the benefit of individuals.

PROVINCIA may be defined generally to be a conquered country, beyond the limits of Italy, which was subject to the Roman state. In contemplating the history of Rome, the most instructive part of it, next to a study of the internal organisation of the state, is the system of provincial government by which the language and laws of Rome were established on a foreign soil. The effects of this system are permanently embodied in the political system of every European state. In order to exhibit a complete view of Roman provincial government it would be necessary to write the history of Rome, but the following outline may be useful.

The geographical sense of the word Provincia was not the original meaning; originally the term expressed the Imperium, which was granted to a consul or prætor beyond the limits of the city. The precise meaning of the word is not certain, and the common etymology is perhaps doubtful; its primary sense however certainly was a power as above explained. In the time of Cicero provincia had undoubtedly obtained the meaning given at the head of this article; and in the latter part of the Republic, the Roman state consisted of two distinctly organised parts, Italy and the Provinces. This distinction, though with considerable modifications, continued under the Empire.

With the extension of the Roman conquests beyond Italy, commenced the system of provincial governments. The oldest provinces were Sicily (B.C. 243) and Sardinia (B.C. 237). Upon the conquest of a country, the commander of the army either gave the conquered country a general organisation, subject to the approval of the senate; or the country was organised according to the instructions of the senate, by the commander and a body of commissioners chosen from the senate, and appointed by it. This original organisation often made very important changes in the existing political forms, but still the conquered people retained their national existence, and were not in all senses incorporated into the Roman state. Originally prætors were appointed to govern the provinces [PRÆTOR]; but subsequently the prætors received a province after the expiration of their year of office at Rome, and were then called propraetores; and towards the close of the Republic the consuls in like manner received provinces, which were hence called consulares, and they were styled proconsules. The division of the provinces was made by lot, and sometimes by agreement among the persons entitled to hold them. By a law of C. Gracchus (Sempronia lex), the provinces of the consuls were annually determined before the election of the consuls, for the purpose of preventing all disputes.

By a senatus consultum of the year 55 B.C., it was enacted that prætors and proconsuls should not have the government of a province till five years after the expiration of their prætorship or consulship. The term for which a province was originally held was one year; but the time was often enlarged. The authority of the governor of a province commenced as soon as he left Rome. His functions in the province were both military and civil; he possessed the Imperium, but he was not called a magistratus. In the later Roman writers the common name for governor is præses (Gaius, i. 6), and sometimes the term proconsul seems to be used generally for the governor of a province. The governor was assisted in the discharge of his duties by a quæstor, who looked after the revenue; and by legati, who assisted in the administration, and were generally appointed by the senate, but sometimes by the governor with the permission of the senate. He had also a numerous train of friends and companions, sometimes called contubernales; and also a regular body of clerks, interpreters, and other servants, who formed a prætorian cohort, a name which was also given, and with more propriety, to the soldiers who formed the governor's body-guard. On a new governor arriving in his province the former governor was required to leave within thirty days.

The province was treated as a conquered country, though the towns retained somewhat of their municipal freedom, but the constitution of many of them at least was re-fashioned upon the model of Rome, though in this respect there were probably considerable varieties. Under the emperors the political organisation of the whole empire became more uniform. The towns had the management of their revenue, and the right of coining; but only towns of the highest class could coin silver. They had a senate like those in the Italian towns, but no magistrates with corresponding powers. The religion of the people was not interfered with.

In some cases part of the land of conquered foreign countries was seized by the Roman state, and let by the censors; or the forfeited land was restored, subject to the payment of a rent. All provincial land differed in some essential particulars from Italian land: it could not be the subject of quiritarian ownership, that is, it had not the privileges of Italian land, and it was capable of being transferred without the forms required in the case of Italian land. There was private property in provincial lands, but the ultimate ownership, in the Imperial period at least, was considered to be in the Cæsar or in the Roman state (populus Romanus). (Gaius, ii. 7.) All provincial lands paid taxes (vectigalia et tributa). But certain provincial towns received as a special favour the Jus Italicum, the legal effect of which was to give the land included within the limits of such town all the qualities of Italian land, and consequently freedom from taxation. Such towns also received, as a part of the Jus Italicum, a free constitution like that of the Italian towns, and with it the various magistrates, decemviri, quinquennales (censors), ædiles; and also jurisdictio, or the power of holding courts of justice. Various towns which enjoyed this privilege are enumerated, in Spain, Illyria, Gaul, and elsewhere. The origin of this privilege is assigned by some writers to the Imperial period; but perhaps it commenced earlier. In all the provinces the regular jurisdiction was in the hands of the Roman governor, who exercised it by himself and his quæstor and legati; and for this purpose he made circuits in his province. In reference to this part of his duties, the governor is sometimes called Judex Ordinarius under the later emperors. These circuits, sometimes called conventus, formed what we may call the divisions of a province for judicial purposes. Thus Pliny (iii. 3) says that Hispania Citerior was divided into seven conventus, which he enumerates. The towns which had the Jus Italicum were not comprised in the conventus; they had their magistrates, in the Italian sense of the term, who had jurisdictio; but there was an appeal to the governor. At these conventus there were present a great number of Roman citizens, who were engaged in commerce in the province, or who were publicani, farmers of the revenues. These conventus, which are frequently mentioned by the Roman writers, were not accidental assemblages of persons, but meetings at stated times and places appointed by the governor, and principally for the purpose of judicial decision on matters in dispute, both between Roman citizens, and Roman citizens and the provincials. The judices were chosen, after the Roman fashion, from the persons who attended the conventus, or circuit courts. It appears that the fundamental laws of a province were not interfered with, for, as we have seen, the soil retained its former legal character, and was not invested with that of Italic soil, and the personal status or condition of Roman citizens was not communicated to the provincials merely as such. Some of the provinces, as Sicily, obtained the Latinitas [LATINUM JUS] from Julius Cæsar, and the Civitas, or complete Roman citizenship, was given to the Sicilians after his death (Cic., 'Ad Att.,' xiv. 12); but this was not the general rule. By means of the edict, which the prætor published on entering upon his duties, and which was often framed upon the prætorian edict at Rome [PRÆTOR], many important changes must have been gradually introduced into the legal system of the provinces, and particularly with reference to matters of contract and forms of procedure, in which there could be no ground for the same distinction that was maintained between provincial and Italic land, and which necessarily influenced the rights of landholders and the forms of action. The prætor had complete jurisdiction in criminal as well as civil matters, and both over provincials and Roman citizens; but a Roman citizen could appeal to Rome in a criminal matter.

A province consisted of a variety of parts. Some towns included in it had from the commencement an alliance with Rome, and were in all respects free. Others, which had been subdued, were declared free, and were not under the immediate jurisdiction of the prætor. The provinces also contained numerous colonies, and both colonies of Roman citizens and colonies of the class called Latinæ. [LATINUM JUS.] Thus towards the close of the republican period a province contained, besides those parts of it which were subject to the complete jurisdiction of the governor, allied towns, free towns, Roman colonies, and Latin colonies. According to this view, the provincia properly comprised those parts and towns which were subject to taxation and to the prætor's immediate jurisdiction. Some writers assert that the Roman and Latin colonies which were sent from Italy into the provinces were in all respects like such colonies in Italy, and that these colonies had quiritarian ownership of the soil, and consequently freedom from taxes. But there is some difficulty about this part of the subject. The privileges called Latinitas, or Latium, were often given to particular towns, one effect of which was to release them from the immediate jurisdiction at least of the Roman governor, and to give them a jurisdictio, or power of holding courts: citizens who filled certain offices (magistratus in such towns), thereby obtained the Roman citizenship. (Strabo, p. 186, speaking of Nîmes.)

The taxes which were raised in the provinces varied in the different countries, but generally consisted in a capitation tax and a property tax: the latter was sometimes paid in money and sometimes in kind. The state did not collect the taxes, but they were sold or farmed: thus, after the Sempronia lex, those of the provinces of Asia were sold by the censors at Rome, and those of Sicily, with some exceptions, were sold in the respective districts of the country, according to a practice established by Hiero. There was also money paid for the use of the open pasture-lands, which the Roman state appropriated to itself. The tolls and port duties, as well as the pasture-land tax (scriptura) were farmed by the publicani. [PUBLICANI.] Besides these and other regular sources of revenue, the province was subjected to many exactions, some of which had a kind of legalised form, and others were merely gifts made to satisfy the demands of the governor, or to secure his favour.

The governor had to give an account of his administration from his own books and those of his quæstor. Originally he gave in this account at Rome; but after the Julian law (B.C. 61), he was required to deposit two copies in the two principal towns of his province, and to send one to the Ærarium at Rome. If the province had ground of complaint against him for mal-administration (repetundæ, peculatus), which was no uncommon thing, application was made to the Roman senate; and the great Romans, who were the patrons and friends of the cities which made the complaint, were also applied to for their aid and interest. If he had betrayed the interests of the Roman state, he was guilty of the offence of majestas. A regular mode of inquiry and trial (quæstio) were adopted for such occasions. Yet little was done without bribing the powerful men at Rome; and the chance of redress against a governor who had even grossly misconducted himself was very small: it was more frequently obtained through the influence of the powerful Romans, stimulated by motives of private hostility to the accused, than through the justice of the case.

With Augustus commenced a new period. He took under his own care the more important provinces, and those which required a large military force; the rest he left to the care of the senate and the Roman people. This arrangement continued, with some modifications, to the 3rd century. Of the provinces of the senate, two were yearly given to consular men, and the rest to those who had been prætors: these governors were all called proconsuls, and they were assisted by legates. They had the jurisdictio both of the prætor urbanus and peregrinus. Quæstors were also sent with them to their provinces: the quæstors had the same jurisdictio that the ædiles had at Rome. It seems however that the power of the proconsuls in their provinces was considerably diminished. The emperor considered himself as the proconsul of his own provinces; and he governed them, though residing in Rome, by his representatives called legati Cæsaris, who had prætorian power. They were selected from those who had held the office of prætor and consul, or were senators of inferior rank. The Imperial governor of Egypt was called præfectus, and he was always an eques. They held their office so long as the emperor pleased, and received all their powers directly from him. These governors of the emperor's provinces were called præsides and correctores in the later periods, though the name præses was applied under the emperors to a governor either of a senatorial or an Imperial province. They had also legati under them; but in the place of quæstors there was a procurator Cæsaris, who was an eques or a freedman of the Cæsar; he looked after the taxes and other dues of the emperor, paid the troops, and attended generally to the business of the fiscus. After the time of Claudius, the procurator had jurisdiction in matters that concerned the fiscus. There were also procuratores Cæsaris appointed by the emperor in the senatorian provinces, who collected certain dues, even in those provinces, for the fiscus, independent of what was the due of the ærarium, or public treasury. Sometimes a small province, or a part of a larger one, was governed by a procurator Cæsaris, with the full power of a præses; this was the case with Judæa, which was a part of Syria, and governed by a procurator who was under the præses of Syria. The general constitution of the provinces remained the same, though as before observed, a greater uniformity in administration was gradually introduced, and from the time of Hadrian the Imperial rescripts and the writings of the Roman jurists contributed to form a body of common law for the whole empire. The taxes continued as before, and were partly paid in money, and partly in kind; but the object of the Romans was always to have them paid in money. The basis of the taxation was a general census of persons and property, which Augustus introduced, and which was taken from time to time. Certain taxes, as tolls and duties, were let, as before, to the publicani. The towns, at least under the early emperors, seem to have retained their privileges; though some modifications were very early introduced; for instance, Augustus indirectly deprived the citizens of the colonies of their suffrage at Rome, a measure which seems to have led the way to other changes. Numerous colonies, chiefly if not exclusively of the class called military, were also established by the emperors in the provinces; and it is to this period that some writers refer the gift of the Jus Italicum to provincial cities.

The inhabitants of the provinces were now divided into three classes as to political rights, Roman citizens, Latini, and Peregrini. The Roman citizens were either Italians resident in the provinces; or members of Municipia and colonies which had the Roman citizenship; or those who had individually obtained this right. The two latter classes had all the privileges of Italians, except with some restrictions as to attaining the senatorian dignity; but many of them obtained the rank of equites. The Latini had not the connubium only and the commercium, but they could obtain the civitas in several ways. The Peregrini had neither the connubium nor commercium; in fact, they had none of those rights which characterised a Roman citizen; but yet they served in the army. By a constitution of Antoninus Caracalla (A.D. 211-17), the citizenship was given to all persons within the Roman empire, and accordingly the distinction of Civis, Latini, and Peregrini ceased, and the two latter classes henceforward only existed among manumitted slaves.

The administration of the provinces gradually came more under the power of the emperor, and particularly as to matters which required a legal decision; under the Christian emperors, though governors and other officers of provinces were appointed, the forms of the old Roman provincia were almost entirely superseded.

(Savigny, *Geschichte des Römischen Rechts im Mittelalter*, vol. i.; and Walter, *Geschichte des Römischen Rechts, &c.*, Bonn, 1840, afford abundant references to original authorities. Incidental information will also be found in the following essays:—'Das Ackergesetz des Sp. Thorius,' *Zeitschrift*, x.; 'Ueber den Inhalt der Lex Rubria de Gallia Cisalpina,' *Ibid.*, x.; 'Ueber das Jus Italicum,' *Ibid.*, vol. v.)

PROVINCIALISM. The difference between the languages of a family and the dialects of a language is only a difference of degree. For example, the Sanscrit, Persian, Teutonic, Greek and Latin, Slavonic, and Celtic, are languages of the Indo-Teutonic family [LANGUAGE]; and the Doric, Ionic, and Æolic are dialects of the Greek language. Although the dialects of a language may present considerable differences both in the roots and forms of their words, the differences are less considerable than those which obtain between languages of the same family. Thus a historian tracing the origin of the Romance languages might doubt whether he ought to consider them as altered dialects of the Latin language, or as cognate languages of the same family. If the Italian, Spanish, and French languages were considered as modern Latin dialects, their various dialects (such as the Sicilian, Venetian, Milanese, Walloon, Valentian, &c.) would be regarded as mere varieties, analogous to the varieties of the Doric dialect as spoken by the different states of the Doric race. (Müller's 'Dorians,' app. v.)

Every language which is spoken by a large population over a wide extent of country, contains several dialects. The number and variety of these is in some cases very great; and considering the importance of this fact as bearing on the origin and history of languages, it has not been sufficiently observed by philologists.

The cause of a want of attention to the multiplicity of dialects in a language is to be found in the ascendency which one dialect of a language always acquires over the others, and the obscurity and neglect to which the latter are consequently consigned. Whenever a country reaches a sufficient height of civilisation to admire and produce literary works, some one of the various dialects of its language is selected by the poets and other native writers, and is cultivated by them. In general, this choice is determined not by any quality of the dialect itself, such as its superior harmony or energy, but by some external circumstance, such as its prevalence near the birth-place or home of the writer, or near the king's court and seat of the government. When a dialect, by any of the means above described, has been distinguished from and raised above the others, it is adopted for all the native literary compositions, both in poetry and in prose. Hence it is still further cultivated, and is moreover thereby rendered more susceptible of ulterior cultivation and refinement. It becomes the general language of the government, of education, of literature, and of polished society; new words are introduced into it from other languages, ancient or modern; and it is learned by foreigners.

The rise and progress of one dialect, according to the general description just given, may be observed to have taken place in every civilised country. In Greece, on account of the multiplicity of independent states into which the nation was divided, each dialect of the language received a separate cultivation. The early historians and philosophers wrote in the Ionic dialect, and lyric poetry was composed in the Doric and Æolic dialects. But after the Persian war, and the great predominance of the Athenians, both in political power and in literature, the Attic dialect obtained the ascendant in Greece and became the common literary language. (Müller's 'History of Greek Literature,' c. 20, § 1, 2.) In like manner, the Tuscan dialect, chiefly on account of the pre-eminence of the Tuscan writers, became the literary language of Italy, and threw into the shade the Sicilian dialect, in which the first essays of Italian poetry were made. But notwithstanding the predominance of the literary Tuscan in Italy, both as the literary language and as a means of communication between inhabitants of different parts of Italy, yet every Italian city or territory has its own dialect, which is habitually spoken, not only by the lower and middle classes, but also by the upper classes when persons from other parts of Italy or strangers are not present. In France, the dialect of the *langue d'oil*, spoken in and about the seat of government, has not only thrown into the shade the other dialects of that language, spoken in the northern portion of the kingdom, and reduced them to the condition of mere patois, but it has also superseded the *langue d'oc*, the language of the south, which had been raised to considerable literary importance by the poems of the Troubadours. The Castilian dialect has obtained a similar ascendency in Spain through the influence of the Castilian writers; and the high German of Saxony has become the literary language of Germany mainly through the influence of Luther's translation of the Bible; although the Suabian dialect received a literary cultivation in the lays of the Minnesingers before any other of the German dialects. The classical English is mainly formed upon the dialect spoken in Middlesex, and the counties in the neighbourhood of London. Its forms differ materially from those of the dialects spoken in the more distant counties, as Devonshire, Somersetshire, Cheshire, Lancashire, and Yorkshire; and still more from those of the dialect of the English which is spoken in the lowlands of Scotland, and in the border counties of England. The latter dialect has received considerable literary cultivation not only from early writers, such as Buchanan, Barbour, and others, but also from Burns, Walter Scott, and their imitators, who have used it with great skill and success for ballad-poetry and tales of fiction; nor have the other dialects been altogether neglected, as several works, particularly poetry, have been produced in them, among which we may mention Miss Blamire and R. Anderson in that of the Borders; for the south of England the very superior works of Mr. Barnes, 'Poems of Rural Life, in the Dorset Dialect, with a Dissertation and Glossary,' 12mo, 1847, and 'Hwomely Rhymes,' 12mo, 1859; and the poems of Edward Capern, the Bideford postman, for the west.

The peculiar dialect of the English which has been formed in the New England States of the American Union is noticed under AMERICANISM.

By a provincial word is meant a word which is not received in the literary language of the time, but which is current among the inhabitants of some district; and provincial words may be divided into the following classes:—

1. Words formerly current in the literary dialect of the language, but which have ceased to be so, and are current only as provincialisms. For example, the word *cantle*, meaning a piece or fragment, and *shard*, meaning cowdung, are used provincially in parts of England, though obsolete in the literary language. They were however literary words in the time of Shakspere, and are used by him in 1 Hen. IV., act iii., and Macbeth, act iii.

Sometimes an ancient classical word, though current provincially in ordinary discourse, is used as a literary word only in poetry or as a technical term. Thus the old words *craven* for coward, and *dank* for damp, which are still used familiarly in the provincial language of some districts, could only be employed as literary words in poetry or in poetical prose; and the old word *soller*, meaning an upper floor, which is current as a provincialism in many parts of the country, is only recognised by the literary language as a legal term, being thus used in the general words of a conveyance ("cellars, sollers," &c.)

2. Words which are not known to have ever been received in the literary language of the country. Many words of this class will occur to any person who consults a provincial glossary of any language. In some cases the word differs widely from any word which occurs either in the modern literary language or in old writers; more frequently however the difference consists mainly in the form. The Scotch dialect presents obvious examples of all these varieties. Sometimes a provincial word is not a dialectical variety of form, but is a corruption arising from ignorance, as *atomy* for *anatomy*, *rusty* for *restive*.

Provincial dialects are chiefly preserved among the humbler and illiterate classes; educated persons generally speak the literary language of the country. Moreover they are chiefly preserved in rural districts; and thus many of the provincial words relate to agricultural subjects. (Preface to Boucher's 'Glossary,' p. xliv.) In Fielding's time, country gentlemen in England often spoke the provincial dialect of their county, as may be seen by Squire Western's language in 'Tom Jones.'

Provincialisms, being either ancient classical words, actually obsolete in the literary language, or diverging words or forms in a parallel dialect, are genuine remains of the ancient language of the country. In this respect they differ materially from the following classes of words:—1. Low, vulgar, or obscene words, which are of universal or general currency, and are not confined to any particular locality. (Grose's 'Dictionary of the Vulgar Tongue,' and the 'Dictionnaire du Bas Langage.') 2. Slang or cant expressions, used by gypsies and thieves for the purpose of concealing the subject of their conversation in the presence of persons who are not their accomplices (called *gergo* by the Italians, *ergot* in French, and *germania* in Spanish). A slang or cant language is often formed among classes of persons following any peculiar pursuit; thus there is a slang of the prize-ring and the stable in this country, and there is said to be a slang among bull-fighters in Spain. 3. Technical words, such as the peculiar language of sailors or miners. 4. Neologisms, such as the words *talented*, *jeopardise*, in English.

Collections of provincial words are important in a philological point of view, as throwing light on the formation, structure, and analogies of languages; they are also important in a historical point of view, as illustrating the changes in the language of a country.

The glossaries of provincial words which have been published in foreign countries are very numerous, though in general they have been made with little philological skill or knowledge, and are meagre in the explanations and illustrations of the meanings of the words. For the English language the most recent and comprehensive general works are those of Mr. J. O. Halliwell, 'Dict. of Archaic and Provincial Words,' 2 vols. 8vo, 1860; and Wright's 'Dictionary of Provincial and Obsolete English,' 1857; and there are glossaries with specimens in prose and verse of the dialects of Norfolk, Suffolk, Sussex, Devonshire (by Mrs. Palmer, the sister of Sir Joshua Reynolds), Somersetshire, Cornwall, Herefordshire, Cheshire, Lancashire, Yorkshire, Cumberland, Westmoreland, and Northumberland; to which may be added Jamieson's 'Scottish Dictionary;' and that of the Northamptonshire dialect, a most comprehensive work, by Miss Baker.

PROVISIONS; PROVISORS. [Præmunire.]

PROVOST, a term having its origin apparently in the Latin *præpositus*, which denotes the chief of any society, body, or community. In France the corresponding word *prévôt* approaches nearer the original form. In that country it is applied to the persons who discharge the functions of many different offices, but in England it is rarely used: instances occur in the heads of certain colleges, as Eton, King's College (Cambridge), &c. But in Scotland it is used to designate the chief officer in cities, as the provost of Edinburgh or of Glasgow, where in England the same officer is called the mayor.

PROVOST-MARSHAL, a term adopted from the French, who called an officer with similar functions the prévôt des maréchaux de France. The English provost-marshal is attached to the army, his duty being to attend to offences committed against military discipline, to seize and secure deserters and other criminals, to restrain the soldiery from pilfering and rapine, to take measures for bringing offenders to punishment, and to see to the execution of the sentences passed upon them.

PROXY. [Lords, House of.]

PRURIGO is a disease of the skin characterised by an eruption of small pimples and a most intense burning sensation of itching. The pimples are usually but slightly if at all red, and the skin between them has its natural colour. They are generally seated about the shoulders, back, and neck, but often also on the limbs, and in severe cases even on the face and over a great part of the body. Their course is always very slow, and they are not infectious.

There are three principal varieties of Prurigo, namely, *P. mitis*, *P. formicans*, and *P. senilis*; and besides these, some others are distinguished by the names of the parts which are in each exclusively or chiefly affected.

The *Prurigo mitis* is the mildest form of the disease. The pimples are very small, and so pale that they can scarcely be discerned, till, by the scratching, which is almost unavoidably resorted to in order to relieve the intolerable itching, their tops are torn off, and become covered by little black scabs of dried blood.

In *P. formicans* all the symptoms of the disease are more severe, and the itching by which they are accompanied is united with a painful burning sensation in the skin, as if, patients say, hot needles were constantly piercing it. Both this and the preceding form of Prurigo may disappear with a slight desquamation in a few weeks, but more commonly a succession of eruptions follow one another, and the disease is prolonged for months or even years. Both of them occur in persons of all ranks and ages, but they are most common in the young and in the old, and among those who enjoy fewest of the comforts of life. They are not attended by any important constitutional disorder.

Prurigo senilis, which is by far the worst form of the disease, occurs almost exclusively in enfeebled children and old people. It usually lasts four years, producing all the time almost intolerable suffering by the intense itching that attends it, and which scarcely admits of relief by any known means. The pimples are usually very numerous, and often hard and prominent; the skin between them is also often thickened and indurated, other eruptions break out upon it, and if cleanliness be not carefully observed, it becomes infested with swarms of lice.

The treatment of the first two forms of Prurigo must consist of a mild antiphlogistic regimen, tepid baths, and the use of alkalies both externally and internally. Stimulants of all kinds greatly increase the pain and itching, but they may sometimes be relieved by the application of ointments or lotions containing small quantities of opium, or prussic acid, or cyanuret of potassium. In the *Prurigo senilis* the regimen must be more nutritious, and tonic medicines are useful; but in this form, as well as in the others, stimulants must be avoided. If the skin is infested with pediculi, the most effectual mode of destroying them is fumigation with the vapour of cinnabar. In this form also sulphur-baths are among the few means that will produce any relief. The alkaline lotions, which may be used in all cases, may be composed of one or two drachms of carbonate of potash to the pint of water, or of from one to three drachms of sulphuret of potash to the same quantity of water, the strength being determined by the irritability of the skin, and being always made less than sufficient to excite any heat or redness in it.

PRUSSIC ACID. [Cyanogen, *Hydrocyanic Acid.*]

PRUSSIC ACID, *Medical Properties of.* This is termed also, from its chemical composition, hydrocyanic acid. Its medical employment, and its connection with medical jurisprudence, from the frequent use of it in cases of death, accidental or intentional, merit the most attentive consideration. But these are unsuited for popular discussion. A few important rules and cautions can alone be furnished here.

Much variation in strength exists in the acid (that is, the dilute acid, for the anhydrous is always of definite strength), owing to different methods of preparation. Thus not only does a difference of strength exist in the acid as it is enjoined to be prepared by the Edinburgh and London colleges, but even in England two preparations are commonly met with, that enjoined by the London Pharmacopœia, which contains 2 per cent. of real acid, and that which has been long known as Scheele's, containing 4 per cent. The substitution of the one for the other in preparing a prescription might lead to serious if not fatal consequences. This anomaly will be removed by the General Pharmacopœia now preparing for use through all Great Britain and Ireland. A still greater difference exists in the strength of the preparations met with in different countries of the Continent. No one in travelling should ever prescribe prussic acid, unless he has previously ascertained what preparation will be employed in compounding the prescription.

As it undergoes decomposition by time, especially if exposed to the light, and is readily volatilised at a high temperature, it should be kept in the dark, and in a cool place. As it is specifically lighter than water, it rises to the surface in watery fluids. The fluid in which it is kept should be well shaken before pouring it out. When employed externally as a lotion, in which case it is used in larger doses than when meant for internal employment, great care should be observed to distinguish it, lest it should be accidentally taken internally. This is attempted to be accomplished by using phials of a peculiar shape and colour. Even its external employment demands great care, for when the cuticle is abraded or cracked, it is readily absorbed, and may prove fatal. The cuticle, even when in a state of integrity, is not proof against the vapour of prussic acid. All bottles containing the acid should be kept well corked, as the vapour is the most potent form which can influence the human frame. It is important to know that this acid is liable to be formed in some medical mixtures spontaneously, without the assistance of heat or distillation. Thus it has been formed in a mixture of carbonate of potash with tincture of hyoscyamus, doubtless by the decomposition of the hyoscyamid furnishing nitrogen (see 'Journ. Pharm. Soc.,' vol. xiii. p. 632).

When first introduced into medical practice, high expectations were formed of the utility of prussic acid. Subsequent experience has moderated these expectations; but there is no doubt that it might be found useful in many instances where it is not employed, the dread of accidents deterring many medical men from using it. Such hesitation displayed by those who know its properties should furnish a salutary caution to all persons against employing it on their own responsibility. The diseases in which it has been most recommended are—affections of the lungs, whether acute inflammation, after the active stage is passed, or those of irritation. Among the former, hooping-cough is unquestionably benefited by it. But here great caution is necessary. Its premature employment, by checking the cough, induces inflammation, often of a very alarming kind. The dose should at first be very small, and most slowly increased. In some works, even emanating from medical men, large doses are most culpably ordered. More relief is obtained in consumption from Conium than from this acid. Some affections of the stomach receive signal relief; others derive not the least benefit from it. The explanation of this appears to be that in the former the causes of the disorder, as well as its seat, are in the stomach itself; while in the latter the pain is felt chiefly in the stomach, but the cause is in the spinal chord. Treatment directed to the spine will in general quickly and often permanently relieve the sufferer. (Teale's 'Treatise on Neuralgic Diseases.') Cutaneous diseases are alleviated by lotions and ointments containing hydrocyanic acid. But the cautions above given must be carefully observed during their employment.

The most useful hints which can be here given relate to the treatment of poisoning by prussic acid. So soon as it is ascertained or suspected that any one has taken an over or poisonous dose, cold water should be dashed over the head and back. The vapour of ammonia (common smelling salts) or of chlorine should be applied to the nostrils; or very dilute liquor ammoniæ may be thrown into the stomach. While these things are doing, other persons may prepare a weak solution of carbonate of potash (common pearlashes will answer); and some sulphate of iron (copperas) is to be dissolved in a large quantity of water. Some of the solution of the carbonate of potash is to be given to the patient, followed immediately by some of the solution of copperas. Phials containing these two solutions might be kept ready prepared in chemists' shops, so as to be at hand instantly. This if done promptly, will save the patient. Artificial respiration, if speedily resorted to, is useful, as is likewise bleeding from the jugular vein. Prussic acid (or its elements, which easily act on each other so as to form this compound,) exists in the leaves of the *Cerasus lauro-cerasus*, or Cherry-laurel, the mere bruising of which developes the characteristic odour and effects. This shrub is unfortunately often confounded with the true Bay, or Cæsar's Laurel, by cooks and confectioners, who use these leaves, (the amount of oil, from difference in the amount of the elements, varies at different periods of the year), to flavour dishes and cheese-cakes, with often fatal effects. Bitter almonds develope prussic acid.

PRY'TANIS (Πρύτανις), the name of the chief magistrate in many of the Grecian states. We read of this office in Corinth, Corcyra, Miletus, Tenedos, Pergamos, Cos, Rhodes, &c. (Wachsmuth, 'Hellen. Alterth.' i., p. 194.)

At Athens, the name of Prytanes (πρυτάνεις) was given to the members of the senate of five hundred, who acted as presidents of the senate and of the assemblies of the people. The senate of five hundred was divided into ten sections of fifty each, who were chosen respectively from the ten tribes into which the Athenian people was divided. Each tribe presided in turn during 35 or 36 days, as the case might be, so as to complete the lunar year of 354 days (12 × 29½). Their period of office was called a prytany (πρυτανεία). As however fifty was too large a number to conduct business conveniently, every fifty was divided into five bodies of ten each, who presided for seven days over the rest, and were therefore called proëdri (πρόεδροι); and from these proëdri an ἐπιστάτης was chosen for one day to preside as chairman in the senate and the assembly of the people; during his day of office he was entrusted with the keys of the treasury and archive office, and with the state seal.

The prytanes had a building to hold their meetings in, where they were entertained at the public expense during their prytany. This building was called the Prytaneion (πρυτανεῖον), and was used for a variety of purposes. (Hermann, 'Political Antiquities of Greece,' § 127.)

PSALMODY, in its widest sense, signifies the Psalms of David set to music and sung. But from the early part of the 16th century the term has been applied only to metrical versions of the Psalms to which short grave airs are either set or adapted.

The practice of psalm-singing may be traced to a very remote date, but we need not refer to any period anterior to that of our Saviour. In St. Matthew's and St. Mark's gospels (xxvi. 30; xiv. 26), we find that, after the last supper, Christ and his disciples "Sung an hymn" ("*or psalm*," says the marginal note), previously to their going "out into the Mount of Olives." St. Paul exhorts the Ephesians (v. 19) to "sing psalms and spiritual songs;" and St. James (v. 13) recommends those who are "merry" to do the like. The corroborative passage in the letter of the younger Pliny to Trajan ('Ep.,' x. 97) stating that the Christians sang hymns to their Christ before daybreak, is well known. The bishops Flavianus and Diodorus ordained that the Psalms of David should be sung by the choir, in the manner of the antiphons. [ANTIPHONY.] Among the inferior orders of clergy in the church of Rome were the Psalmistæ, whose first institution appears to have been at the commencement of the 4th century. It is believed that this order was established for the purpose of encouraging and regulating the ancient psalmody; for, says Bingham, "from the first and apostolical age, singing was always a part of divine service, in which the whole body of the church joined." (i. 295, *et seq.*) The service of the ancient church usually began with psalmody, according to St. Jerome. (Hieron., 'Ep.,' 22, 'Ad Eustach.') It was also the exercise and recreation of the Eastern churches in their nocturnal vigils; and, indeed, at all times in the church, St. Augustine remarks, was psalmody used to fill up vacant intervals. (Aug., 'Ep.,' 119, 'Ad. Januar.')

By degrees the greater part of the psalm-tune was surrendered to a single voice, the congregation joining only at the close. This led to a more scientific and perhaps a more refined mode of singing, requiring superior knowledge; and thus, the body of the people becoming incapable of taking a share of the performance, the service was left in the hands of professed musicians. This was encouraged by the Church of Rome, during her long dominion, because it still farther divided the clergy and laity: but Huss, and afterwards Luther and Calvin, restored to the people their share in the divine service, furnishing them at the same time with the means of performing it in a manner agreeable to themselves, and conformably to what they conceived to be the true principles of public worship. With this view the Psalms were turned into metre, tunes were composed or adapted, and the practice of psalmody soon became a marked distinction of those who departed from the Church of Rome. Luther, however, was friendly to harmony, or music in parts; the severe Calvin, on the contrary, sternly refused to admit anything but simple unaccompanied melody. The design of the reformers was seconded by Clement Marot, who translated the first fifty Psalms into French verse. These, adapted to popular airs, became exceedingly fashionable, and the length to which the new amusement of singing sacred songs was carried by the monarch of France and his courtiers, is fully described by Bayle (in a note on Marot), and after him by Warton ('Hist. of Poet.,' sect. xlv.), as well as others. Theodore Beza, by his version of those Psalms which Marot left untouched, completed the hundred and fifty. Most of the melodies to these, as used by the first Calvinists, are commonly attributed to Claude Goudimel and Claude Le Jeune, distinguished French composers; but Bayle, on apparently good authority, ascribes them to one Guillaume Franc; while some think that they were chiefly German. It seems almost certain that a few owe their birth to the great reformer himself, of whose musical knowledge undoubted proofs remain; and it is equally clear, for the reason before mentioned, that the *harmonised* tunes of Goudimel and Le Jeune were not admitted into Calvin's places of worship, though probably their melodies were.

At nearly the time that Marot's translation of the Psalms appeared, Sternhold and Hopkins, with several coadjutors, produced an English version, to which were adapted many of the best German and French tunes; and Strype says, "it is certain that Sternhold composed several at first for his own solace. For he set and sung them to his own organ, which music King Edward VI. sometime hearing (for he was a gentleman of the Privy Chamber), was much delighted with them." ('Historical Memorials,' bk. i., chap. 11.) But if this versifier possessed as little musical as poetical taste, it is fortunate for him that his compositions do not remain to demonstrate that he was no less unskilful in one art than in the other. It is, however, to be presumed that there having been many very able musicians in the service of the youthful Edward, they contributed something in aid of Sternhold's design. But it is now generally supposed that for the majestic melody to which our 100th Psalm is adapted, we are indebted to the genius of Claude Le Jeune. This forms the *taille*, or tenor part, of his 134th Psalm, as printed in the Leyden edition of 1635; and it is necessary to remark that he, as well as others in his time, made a practice of giving the subject, or air, as a kind of *cantus firmus*, to the tenor voice.

The first complete collection of psalm tunes for four voices deserving notice was published in 1621, by Thomas Ravenscroft, Mus. Bac., to which Tallis, Morley, Dowland, and all the great masters of the day contributed; the name of John Milton, the father of the poet, also appears there, as the composer of *York* and *Norwich* tunes. The editor supplied many, some of which are still in use; and to his collection all the numerous works of the kind since printed have been much indebted. About the year 1671, John Playford, a good musician, and a most useful industrious editor, printed, in 8vo, 'The Whole Book of Psalms in three parts,' in which he has judiciously given the melody to the soprano voice, to which it naturally belongs, and it ever since has retained its place. A few of the tunes in that collection are supposed to have been composed by Playford himself, whom Sir John Hawkins considers as "the father of modern psalmody." Subsequently to the last edition of his work, valuable additions were made to the stock of genuine English psalmody, by Dr. Croft, Courteville, Carey, &c., and Handel is the reputed composer of the sweet music to the 104th Psalm, which still continues in our chimes, and as the dirge at the soldier's funeral. Dr. Miller, of Doncaster, effected a considerable improvement in psalmody by his 'Psalms of David for the use of Parish Churches,' in which the version of Tate and Brady was employed, and drove Sternhold and Hopkins from many of their strongest positions. The extraordinary success of that work, which made its way into the remotest parts of Great Britain, raised up a host of rivals and the number of publications and of new tunes has since increased beyond calculation. The popular works of all foreign composers have been made contributory to that love of novelty which carries its influence even into the temples of religion, and many organists have fancied themselves qualified and privileged to print a collection for the use of the church or chapel in which they officiate. Hence the music which had become almost a part of our Liturgy is falling into desuetude, and modern hymns—not always the most appropriate or the best in point of composition—threaten finally to banish the fine characteristic harmony of our ancient psalmody. (Bingham's 'Antiq.;' Bayle; Strype; Warton's 'Hist. of Poet.;' Mason's 'Essay;' Hawkins; Burney; Dr. Vincent 'On Psalmody.')

PSALMS (ψαλμοί, from ψάλλω, *to strike gently*, and so, to play on a stringed instrument) denote generally the poems which form one of the canonical books of the Old Testament. This book is called in Hebrew סֵפֶר תְּהִלִּים (*sepher tehillim*), 'the book of praises.' Except in thirty-four cases, the Psalms have titles, which, though they are no part of the original, are of great antiquity. Some designate the writer or the subject, or the occasion, and some are not to be understood.

The book of Psalms is often called the 'Psalms of David,' though many of them were not written by him. The authors of the Psalms named in the titles are Moses, David, Solomon, Asaph, Heman, Ethan, Jeduthun, and the sons of Korah. Between the earliest and latest of the Psalms, a period of about one thousand years seems to have intervened.

According to the Masorites, the Psalms are divided into five books, of which the first ends with Psalm xli., the second with Psalm lxxii., the third with Psalm lxxix., the fourth with Psalm cvi., and the fifth with Psalm cl. The first three books end with 'Amen and Amen;' the last two with 'Hallelujah.' This division existed in the time of Jerome, but how long before is uncertain. It is thought to have been made for the purpose of rendering the Psalms in this respect like the Pentateuch. The collecting of the Psalms into one book is generally attributed to Ezra.

The Psalms afford an exemplification of every variety of Hebrew metre, and they are pervaded by the highest poetic feeling. They were designed to be rehearsed in the worship of God with the aid of instrumental music. David appointed the singing of the Psalms by a company of persons, trained for this purpose, in the worship of the tabernacle. (1 Chron., vi. 31; xvi. 4-8.) This practice was continued by Solomon in his Temple (2 Chron., v. 11-13), and, after the interruption occasioned by the Captivity, it was renewed by Ezra. (Ezra, iii. 10, 11.) The New Testament furnishes evidence that Psalmody formed, in the time of Christ and his Apostles, a part of the worship of God, and the Christian church has in all ages followed the example. The book of Psalms obtained extraordinary attention among the early Christians. Theodoret, who wrote in the first half of the 5th century, says ('Preface to the Psalms') that while most men paid little or no attention to the rest of the Scriptures, they were so familiar with the Psalms, that in their houses, in the streets, and in the highways, they enjoyed profit and delight by the singing of these divine odes.

The canonical authority of the book of Psalms has never been disputed. There have been many works written as commentaries or explanations of the Psalms, and more than one translation. Indeed the version in the authorised translation of the Bible and that in the Prayer Book vary, though not much. Among the best works on the subject may be mentioned Tholuck, 'Uebersetzung und Auslegung der

Psalmen,' 1843; and Hengstenberg, 'Commentär über die Psalmen,' 1843-5.

PSALTERY, an ancient musical instrument of the harp kind; in use among the Jews, and supposed by Blanchinus to have been the נֵבֶל, *nebel* (whence *ναβλα* and *nablum*), mentioned in several of the Psalms. Whether this instrument was square or triangular, and played on by the finger, or struck by a plectrum, seems doubtful; the probability is that it took many forms, and was acted on both ways. Blanchinus makes it square, Luscinius triangular. According to Mersenne, and after him Kircher, the Psalterion, as they denominate this instrument, adopting the Greek term, was in shape a trapezium, and similar to that which is still in use under the name of dulcimer. [Dulcimer.]

PSEUDERYTHRIN. [Lichens, Colouring matters of.]

PSEUDO-ACETIC ACID. A name given to a peculiar acid strongly resembling acetic acid, said to be occasionally formed during the manufacture of tartaric acid.

PSEUDOMORPHINE. [Opium, alkaloids of.]

PSEUDORCIN. [Erythric Acid.]

PSEUDOSULPHOCYANOGEN. (Cy_3HS_6?) When a solution of sulphocyanide of potassium is treated with a current of chlorine, or by boiling dilute nitric acid, an orange-yellow coloured precipitate is obtained which seems to possess the above composition. It is insoluble in water, alcohol, and ether, but dissolves in concentrated sulphuric acid. When heated, it yields bisulphide of carbon, sulphur, and hydromellon:—

$$\underbrace{3Cy_3HS_6}_{\text{Pseudosulpho-cyanogen.}} = \underbrace{6CS_2}_{\text{Bisulphide of carbon.}} + 6S + \underbrace{3NHCy_2}_{\text{Hydromellon.}}$$

PSILOMELANE. One of the native forms of binoxide of manganese. [Manganese.]

PSORA. [Itch.]

PSORI'ASIS is a disease of the skin distinguished by slightly raised red patches of various extent and form, and generally covered with whitish scales. Several varieties of the disease have received different names, according to the form and severity of the eruption in each, and many others, according to the part chiefly or alone affected. The former varieties are *Psoriasis guttata*, *P. diffusa*, *P. gyrata*, and *P. inveterata*; among the latter are *P. ophthalmica*, *P. palmaria*, &c.

Psoriasis guttata is a mild form of the disease, consisting of small red patches two or three lines in diameter covered with very fine white scales. It occurs in various extent on all parts of the body, but most rarely on the face. At first small red spots appear, and soon after present white scales at their centres; then the spots gradually enlarge and the scales increase in number, till the redness begins to fade at the centre, and as the scales fall off, the skin slowly assumes its natural colour. The eruption is attended by a moderate itching, and by very slight symptoms of general disorder.

P. diffusa is in every respect a more severe form of the disease. The spots are large and irregular, and often confluent, and covered with thick scaly incrustations. It appears most frequently on the limbs and around the joints, often covering the whole of a limb with one scaly or raw-looking patch, and sometimes occurring at once and with equal severity on several parts of the body. The skin beneath the scales is very tender and irritable; it often cracks and discharges a thin ichor, which concretes about the fissures, and is attended by considerable pain and irritation, and some constitutional disturbance. The eruption often breaks out successively in different parts of the body, so that it is common for the disease to be protracted for several months and even for years.

P. inveterata is only (as its name implies) a yet less curable form of the same disease. The skin has its whole texture thickened and hard, its surface is covered by a furfuraceous deposit, and in the neighbourhood of the joints it is often very deeply and painfully cracked. The preceding forms are commonly met with in those who are otherwise in pretty good health; but this rarely occurs, except in those whose constitutions are enfeebled by long disease or want.

P. gyrata is a slight but very rare variety, distinguished by the patches occurring in stripes of a singularly tortuous or serpentine form.

Of the local varieties of Psoriasis, the most interesting is that which occurs on the palms of the hands, and which, being most frequent in those who work with light powders, and other irritating substances, is commonly called bakers', or bricklayers', or washerwomen's itch.

Psoriasis, in all its forms, is difficult of cure. The general condition of the health being corrected by the means that in each case seem appropriate, the remedy which is most frequently successful in cases of long standing is arsenic, in the form of from three to five drops of the Fowler's solution, three times a day, for an adult. Active purging is also often useful, especially in recent cases and in young subjects. Another good remedy is tincture of cantharides, in doses of from three to five drops (for an adult) in water once or more in the day; but the effects of both this and the arsenic require to be carefully watched during their administration, and they must be discontinued as soon as they appear to produce any sickness or heat in the stomach. The arsenic should be taken at meals, if not it is more likely to produce sickness. In addition to these, various other internal means have been recommended, as decoctions of dulcamara, mezereon, and orchis, antimony, sulphur, &c. Indeed, in many cases it is found necessary to try one means after another without any rule, till one is found which produces benefit. External remedies are generally of less value than internal. The most approved are vapour and sulphur baths, and ointments or lotions containing very small quantities of nitrate of mercury, or white precipitate, or creasote, or alkalies. These however can only be employed in the later stages of the disease: in the earlier, the mildest fomentations give relief, and all kinds of irritants must be carefully avoided.

PSYCHE (Ψυχή). Apuleius is the first writer who relates the loves of Cupid (Eros) and Psyche ('Metamorph.', lib. iv., v.). According to his account, Psyche, the daughter of a king, was the most lovely creature that the world ever beheld. People flocked from all parts to see her, and neglected the worship of Venus, who became in consequence jealous of her, and commanded her son to inspire Psyche with love for some mean creature. Cupid, however, instead of obeying the commands of his mother, became enamoured of Psyche, and made her his wife. She was, however, subsequently deserted by him for disobeying his injunction not to seek to behold his face. Inconsolable at her loss, she wandered through the world in search of him, and after enduring many trials and sorrows was at length reunited to him. Jupiter conferred upon her immortality, and her union with Cupid took place with the approbation of Venus and the other deities. A child was soon afterwards born to them, who was called Pleasure.

This tale is now commonly regarded as an allegory, representing the union between the divine love and the human soul. It probably had its origin in the Orphean mysteries. The word Psyche signifies in Greek both "soul" and a "butterfly." We frequently find in ancient works of art Cupid pressing Psyche to his bosom in the form of a butterfly. When Psyche is represented with a human form, the wings of the butterfly are usually placed on her shoulders.

Though Apuleius is the first writer who relates the legend, it is certain that the fable of Eros and Psyche must have been current long before his time, as there are many works of art representing some portion of this subject of a date long anterior to that at which Apuleius lived; though none probably are prior to the Roman period.

PSYCHROMETER (*ψυχρος*, cold, and *μετρον*, a measure), a term applied to the wet and dry bulb thermometers used as a Hygrometer. [Hygrometry.]

PTELEIC ACID. An acid of problematical existence said to be produced when mesitic chloral is dissolved in solution of potash.

PTOLEMAIC SYSTEM. A few words of general explanation constitute all that can be given under this head, and we are not now speaking with particular reference to Ptolemy, but of the astronomical part of that system which, founded on early metaphysical and physical doctrines, adopted by Plato and Aristotle, reinforced by mathematical hypotheses drawn from Hipparchus and Ptolemy, received by the Mohammedans and by them imparted to the Christians of the middle ages, was the doctrine universally established in Europe till the 17th century. As a whole it combines the physics of the Aristotelian school, the geometry of Euclid and his successors, the sexagesimal arithmetic of the Greeks, and the astronomy of Hipparchus and Ptolemy, with some slight additions from later names. The geometry remains, the arithmetic has been supplanted by the decimal system of the Hindus; the physics and astronomy stood and fell together; and as under the words Ptolemaic System the astronomy is particularly meant, we only here notice the physical notions so far as they are connected with it.

The early separation of perceptible matter into the four elements of earth, water, air, and fire, with observation of the relative places they appear to assume, led to the formation of an elementary system. Earth (and solids generally) sink in water, while air rises in water, and flame in air. Hence the notion that the mass of the earth is the central body of the universe; above is a region of water, through which rises that portion of earth on which men and animals live. Above this is a region of air, and above this again a region of fire. Nothing is at rest until it arrives at its proper or natural place, and all the motions of a part separated from its whole are rectilinear; fire rises, and bodies fall, in straight lines. Gravity and levity are only the efforts of bodies separated from their natural places to return to them.

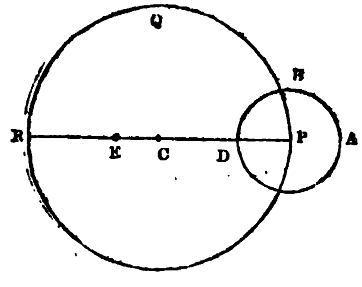
Above the earth and the elementary zones which encompass it, are other successive zones, called heavens. Each heaven contains an immense crystal spherical surface, to which one of the heavenly luminaries is attached, or would be attached, if it moved uniformly in a circle, as it would then do if the crystal sphere were made to revolve uniformly. But the varied motions of the heavenly bodies made it necessary that smaller orbs should be placed with their centres upon the larger ones, as hereafter noticed, and that the planets should move with the smaller ones. It is hardly to be believed (at least so many think) that Ptolemy and the mathematicians received these orbs, in the physical sense, or as anything but hypotheses for representing the actual motions of the planets; it is certain however that the actual solid orbs continued to be received till a late period. Copernicus uses language which has exposed him to some suspicion of receiving them; and even in the final scholium of the Principia Newton thinks it worth while once more to overturn them, as Tycho Brahé had done before him, by showing that if they existed, the comets could not move as they were known to move.

The first heaven is that of the moon; the second that of Mercury; the third that of Venus; the fourth that of the Sun; the fifth that of Mars; the sixth that of Jupiter; the seventh that of Saturn; the eighth that of all the fixed stars. The heavens of Aristotle end here; later theorists add two more, a ninth, to make the precession of the equinoxes, and a tenth, or primum mobile, to make the diurnal revolution. All beyond this is the empyreal heaven.

The office of the *primum mobile* is to revolve from east to west in twenty-four hours, carrying with it (but how, we do not know) the whole of the subordinate heavens, and making all the phenomena of day and night. All the heavenly motions are to be circular and uniform; this doctrine of the Platonic school is the keystone of the whole system. The poles of the primum mobile are those of the equator; but the ninth heaven moves slowly round the poles of the ecliptic, carrying the whole system forward in longitude, so as to give the phenomena arising from the precession of the equinoxes. The heavens of the other heavenly bodies move round with the mean motions of the bodies depending upon them; and this completes the general view of the system.

The details of the heavenly motions were for the mathematicians only, who dropped the orbs, and only took such circles out of them as were necessary in the explanation of the motions.

Without entering into all the details connected with this explanation, which are rather complicated, and require besides some knowledge of the actual inequalities of the planetary motions, we shall take the two leading circumstances of those motions, namely, their not being uniform, and their being sometimes direct, or according to the order of the signs of the zodiac, and sometimes retrograde. One way of explaining the simple irregularity of motion was by supposing the orb of the planet to be a sphere, and revolving uniformly, but not concentric with the earth. Let the earth be at E, and let the circle P Q R revolve uniformly round the centre C, or let the planet P revolve uniformly in that circle. Consequently, the nearer the planet is to E, the faster it will appear to move, and the contrary, that is, a spectator at E will see the planet moving most slowly when at P, from whence the apparent motion will be accelerated until it arrives at R, and retarded while it returns to P on the other side. The circle P Q R is called an eccentric. This hypothesis was a tolerably good representation of the motion of the sun, when E C was taken in a certain specified proportion to the radius C R; and if the sun had been placed at E, it would have made a sufficient representation of the motions of the planets, at least for the earlier periods of observation. But it must be remembered that though an acceleration and retardation would thus be established, it would not be precisely that of the planets, though sufficiently near, as remarked, to represent the results of rough observation.



The mode of obtaining the alternate progressive and retrograde motion is as follows:—Let P be the centre of a circle called an epicycle, and let P revolve uniformly round the earth at C, while the epicycle revolves uniformly round its centre, carrying the planet on its circumference, or while the planet revolves uniformly round the epicycle. Let the epicycle itself move in the direction P Q R, and let the planet on the epicycle move in the same direction, or A B D. If then the times of revolution of the planet in the epicycle be sufficiently great compared with that of the epicycle itself, its retrogradation at D will more than compensate for the progression of the epicycle itself; that is, the planet will appear to a spectator at C to move in a retrograde direction, when it is in the lower part of the epicycle. But in the higher part, at A, both motions conspire to make it appear to move directly. There must consequently be an intermediate point at which the direct motion ceases and the retrograde begins; and near this point the planet will appear stationary.

It is by a complicated use of these methods that Ptolemy succeeds in giving a tolerable account of the angular motions known in his time; but they fail in placing the planet at the right distance from the earth, though they may place it nearly in the right longitude. We imagine that in modern times very few persons have taken the trouble to make themselves acquainted with the details of this system. These may be learnt, with some trouble, from Delambre's account of the Syntaxis ('Hist. Astron. Anc.'), but they are explained with much more clearness in Mr. Narrien's 'Origin and Progress of Astronomy,' London, 1833. Those who would have Ptolemy's own explanation at less expense of time than is necessary to find it in the Syntaxis, should look at his short tract, περὶ ὑποθέσεων τῶν πλανωμένων, which was published with the Sphere of Proclus, by Dr. Bainbridge, in 1620. The physical views may be collected, as well as the mathematical ones, from the 'Philolaus,' the first work of Bouillaud, Amsterdam, 1639. [Trochoidal Curves.]

PTOSIS is a dropping of the upper eyelid, which the patient cannot by any voluntary exertion raise from before the globe of the eye. In some cases this effect is produced by great inflammatory swelling of the eyelid, with effusion of serum into its tissue; but in those cases to which the name of ptosis is more especially applied, it results from a paralysis of the third pair of nerves [Brain, in Nat. Hist. Div.], or only of that branch of it which supplies the levator palpebræ muscle [Eye, in Nat. Hist. Div.] These are in fact cases of local paralysis, and must be treated, without any particular reference to the eye, according to the principles on which paralytic affections in general are managed. [Paralysis.]

PTYALIN. An albuminous matter constituting about one-third of the soluble solids of the saliva. It converts starch into dextrin and sugar.

PUBERTY (*Pubertas*), the age at which the period of boyhood or girlhood ends, and that of adolescence begins. [Age.] The word is derived from *pubes*, which in its primary signification means the down or soft hair that generally begins to grow on young people about that time. Puberty appears at various ages, according to the climate, the circumstances connected with education, and the constitution of the individual. The usual period in this country is from the twelfth to the fourteenth year for females, and from the fourteenth to the sixteenth for males. In the northern parts of the island it is often a year or two later in both sexes. Women in all countries reach the period of puberty one or two years before men; and the inhabitants of warm before those of cold climates. In the hottest regions of Africa, Asia and America, girls arrive at puberty at ten, or even at nine years of age; in France not till thirteen, fourteen, or fifteen; whilst in Sweden, Russia, and Denmark this period is not attained till from two to three years later.

Occasionally however an extraordinary precocity exhibits itself in the development of both males and females. It is not necessary to dwell at any great length upon instances of exemplification, which may be traced in great numbers in the writings of physiologists who have been curious upon this subject. Those who are desirous of doing so may turn to the 'Journal des Sçavans' for 1688, and the 'Philosophical Transactions' for 1745; and other instances in Dr. Good's 'Practice of Medicine.'

The period which commences with puberty is, both as regards the mind and the body, one of the most important epochs of human existence; for, says Dr. Copland ('Dictionary of Practical Medicine'), during it the natural development of the sexual organs imparts a health and tonic excitement throughout the economy, bringing to their state of full perfection all the organs of the body, and all the manifestations of mind, excepting those that are derived from experience. It is chiefly during this period of life that the mind becomes stored with ideas, derived both from the learning of the ancients, the science of the moderns, and the arts and accomplishments of highly civilised life; and is more particularly and more ardently engaged in decomposing the information thus acquired, and recombining it in new and useful attractive forms.

PUBLIC HEALTH. [Sanitary Legislation.]

PUBLIC LIBRARIES. [Libraries.]

PUBLIC POLICY. This expression sometimes occurs in the reports of law cases, and sometimes the expression "policy of the law" occurs; neither of these expressions has a sufficiently definite meaning. An example will best explain how they are applied. One man may agree with another for a certain valuable consideration to give up to him some trade, art, or business, and agree that he will not carry on the same within the realm, with the object of securing to the purchaser all the benefit which can be derived from his bargain. If he who has received the money happens to break his contract by commencing the same trade, art, or business in a distant part of the realm, as at the Land's End or Newcastle-on-Tyne (the original place of business being London), and an action be brought on the contract, it could not be maintained, because the contract itself was *against public policy*, which would be explained to mean that the public ought not to be deprived of a man's services by such an unreasonable contract. Yet if the contract were that the trade or business should not be exercised within a certain limited distance of London, the contract would be valid.

PUBLICA'NI. The publicani were a body of persons in the Roman state who farmed the public revenues (*vectigalia*), from which circumstance apparently their name is derived. ("Publicani autem dicuntur qui publica vectigalia habent conducta," 'Dig.,' 39, tit. 4, s. 12.) They were numerous as early as the 6th century of the republic, and they continued to exist under the emperors. The publicani formed various societies or partnerships, which had a corporate character. Each societas had a magister, or chief manager, at Rome, and a deputy magister (*promagistro*), with numerous associates and assistants, in the provinces. [Provincia.] The revenues, which were chiefly leased to the publicani, were tolls, harbour duties, and the scriptura, or the tax that was paid for the use of the public pasture-lands. The publicani had their under-lessees (*portitores*, *τελῶναι*, Luke v. 27, 29) and collectors. Numerous slaves were also employed by them in collecting the taxes; and this body of men was comprehended under the term of a *familia publicanorum*. In our translation of the New Testament these inferior officers are called "publicans," and are mentioned together with "sinners," a distinction to which they might be partly entitled for their occasional oppressive conduct, and partly to the general dislike of all the world to tax-collectors. It appears that Matthew, who was a Jew, was a publican (Matt. ix. 9), the only civil employment held by a Jew under the Romans.

The publicani undertook to pay fixed sums for the taxes of a particular district or place. The contract was often made by a single person on behalf of himself and others. It was the business of the censors to let the taxes. The publicani gave security to the state for the due performance of their contract; and their property, as well as that of their sureties, was liable to the amount of their obligations.

Among the remedies which the publicani had against those who were bound to pay vectigal, was the *pignoris captio*, which seems to have been a kind of distress (Gaius, iv. 28); but after the old forms of action were changed, it was not usual actually to seize the property, but a fiction was introduced into the formula, by virtue of which the person who owed the vectigal might be condemned in a sum of money equal in amount to what he must have paid in order to redeem his property if it had been seized.

PUERPERAL DISEASES. Under this term are included all those diseases which arise out of the state of pregnancy: they are not, however, as the name would seem to imply, peculiar to this condition, but incidental only; and they are so far modified by it as to require some allusion to their character and mode of treatment. Among the most alarming of these diseases, and the earliest to make their appearance, are puerperal convulsions; they consist of epileptic seizures, and their character differs in no respect from the ordinary epileptic fits already described in the article Epilepsy; we therefore shall merely observe in the present place, that convulsions are liable to occur at any time after the sixth month of utero-gestation; but for the reasons about to be stated, the majority of cases are met with during labour. When they occur after delivery, they are generally connected with a loaded state of the large intestine, or with a state of exhaustion from hæmorrhage. The cause of these attacks must be looked for in the state of the viscera and large blood-vessels at this period: during gestation, these parts are subjected to a constant and increasing degree of pressure from the gravid uterus, the natural tendency of which is to produce local congestion of the circulating fluid, and an undue accumulation of the excretions within the intestines. At the time of parturition this pressure is materially augmented by the contractile efforts which are made to expel the infant; and the mechanical obstacle thus offered to the flow of blood through the abdominal aorta, determines it in unnatural quantity to the brain. Hence this state of things, if not remedied, may not only produce the disease we have just been considering, but may even give rise to apoplexy. The treatment is obvious, and consists in relieving the vascular system by general and topical bleeding, and unloading the intestines by brisk cathartics.

A recent writer attributes puerperal convulsions to the presence of urea in the blood.

But by far the most important and the most dangerous of puerperal diseases is puerperal peritonitis [Peritonitis], called also puerperal inflammation, puerperal fever. It usually attacks women a few days after delivery, and seems to have no connection with the duration or the severity of labour. This fatal disease varies so much in the type of the inflammation as to be scarcely recognised as the same affection in different individuals and at different periods, the accompanying fever being sometimes strictly inflammatory, and at other times typhoid. In its most dangerous form it is characterised by a remarkable prostration of the vital powers, and by a countenance expressive of extreme anxiety and distress. The pulse is frequent and feeble; the abdomen tympanitic, and unable to bear the slightest pressure; the bowels are constipated, and vomiting is not an unfrequent attendant. As the disease proceeds, the lochial discharge and the secretion of milk are suppressed; and towards its termination, a total cessation of pain sometimes occurs, and the patient dies, often in full possession of her consciousness to the last. This severe form of puerperal fever is most frequently epidemic, and many believe it to be highly contagious. The lesions met with in this disease are chiefly manifest in the peritoneum; but in the worst cases, the substance of the uterus itself, and the large veins in its vicinity, present evidences of inflammation. The treatment of puerperal fever is peculiarly difficult; "every case," observes one of our most celebrated accoucheurs, "must be isolated and studied alone, and looked at by itself, and its management must depend upon its type and its stage." Bleeding, general and topical; counter-irritation, by means of blisters or spirits of turpentine, applied to the abdomen; purging, by the exhibition of the last-named medicine, or by large doses of calomel; and the latter, given to excite ptyalism, have been the principal remedies used for combating this formidable malady. But the prostration of the vital powers is in some cases so extreme as to afford us little chance of putting into requisition the only means which we possess of combating the inflammatory symptoms.

A form of disease sometimes occurs after delivery which, from its resemblance in some particulars to the one we have just alluded to, requires notice. It is due to stomachal and intestinal irritation; and is ushered in by rigors, followed by great heat of skin, a full and frequent pulse, and loaded tongue. The abdomen may be tumid and painful on pressure, and the head may be affected by symptoms of phrenitis, as intolerance of light, noise, wakefulness, and delirium. The affection of the head and that of the abdomen frequently co-exist or alternate in the same case; and this conjunction of the two affections serves to assist in the diagnosis between peritonitis and the present complaint. As it is of the greatest importance in a therapeutic point of view to distinguish puerperal inflammation from intestinal irritation, much may be learnt by the exhibition of large injections of warm water, an examination of the evacuations, and an observation of the effects thus produced upon the disease. In intestinal disorders, the fæces will be found to be scybalous, or at least offensive and dark-coloured, and in large quantities; and the relief obtained will be found to depend upon the proper evacuation of the bowels. Another characteristic of intestinal irritation is the susceptibility to fainting upon blood-letting. The treatment of this disorder may be summed up in the words of Dr. Marshall Hall. "In peritonitis," he observes, "the freest blood-letting must be aided by purgative medicines; whilst in intestinal irritation, the freest and fullest evacuation of the intestines must be aided by blood-letting; for although both blood-letting and purging are to be used in every case, yet the former is the remedy in inflammation, and the latter in intestinal irritation." In describing the last-mentioned disease, we have alluded to the combination of cerebral symptoms, which so frequently are present. This disturbance of the intellectual functions is sometimes so great and so continued, as to lead to the supposition that the brain is the seat of some active inflammatory disease; and were we, acting upon this supposition, to have recourse to antiphlogistic remedies only, we should probably lose our patient. This alarming disorder has been termed puerperal insanity, or puerperal mania. It comes on rather insidiously: there is a little excitement during the day and sleeplessness at night; then delirium, and then actual mania; the pulse is somewhat accelerated, the tongue furred, the skin hot, the bowels costive, and the secretion of milk diminished. It seems to arise from a combination of causes acting upon an originally irritable temperament, but rendered still more so by intestinal disorder and hæmorrhage, or by the debility consequent upon suckling. Blood-letting in these cases is generally fatal; the treatment consists in regulating the bowels and preserving extreme quiet of mind and body, with a nutritious but not stimulating diet.

When speaking of puerperal fever, it was observed that the large veins in the vicinity of the uterus frequently presented traces of inflammation. Uterine and crural phlebitis, however, occurs as a distinct disease, and has been described under the terms of phlegmasia dolens, œdema puerperarum, the white swelling of lying-in women, &c.; but it is only within a few years that the true nature of this disease has been fully understood, having been first pointed out to the profession by Dr. Robert Lee. It may appear as early as the fourth day after delivery; but, in the majority of cases, it is not till the second or third week that it makes its appearance; and, in many instances, attacks women who are recovering from puerperal fever. It is ushered in with rigors, and these are succeeded by heat, thirst, and other symptoms of pyrexia. There is a sense of pain, first experienced in the uterine region, and gradually descending in the course of the iliac and crural veins down one leg, accompanied by swelling, and great tenderness upon pressure along the course of the vessels, which are hard as a cord, and roll under the fingers. In some cases an erythematous redness of the integuments of the limb is met with; but in the majority they are smooth, shining, tense, and colourless. The power of moving the limb is completely lost, and it is greatly and uniformly swollen throughout its whole extent. Sometimes, after the inflammation has subsided in one limb, the other is attacked in a similar way. The pain and febrile symptoms usually diminish within a few days after the occurrence of the swelling; but sometimes the pain is excruciating throughout the whole period of the acute stage of the disease. The duration of the acute stage is various in different individuals; in the greater number of cases it terminates in two or three weeks; but the limb still remains powerless and œdematous. In some women the limb does not return to its natural state for many months, or years, or even during life. The appearances on dissection which are met with in this disease are similar to those which characterise inflammation of the veins generally. The causes of this affection are supposed to be owing to the orifices of the veins in the lining membrane of the uterus being left open after the separation of the placenta, by which a direct communication is established between the cavities of these veins and the atmospheric air. The treatment of phlegmasia dolens consists in the local abstraction of blood by leeches applied to the groin, and in the course of the large venous trunks of the limb; hot fomentations to the part, and the administration of diaphoretics and saline purgatives. After the inflammatory symptoms have subsided, the limb may be supported by a bandage, and slight frictions made use of.

There is a disorder occasionally met with in the puerperal state, which, from not being mentioned in the article HÆMORRHAGE, must be alluded to in this place. The symptoms about to be detailed are owing to loss of blood, uterine hæmorrhage during and shortly after parturition being not an unfrequent occurrence. The more immediate effects of hæmorrhage are fainting; and where the loss of blood has been great, this symptom is sometimes so prolonged as to be not only dangerous, but fatal. It is the more remote consequences of loss of blood that we are to speak of in this place: we have seen already how a combination of this with intestinal disorder and other irritating causes gives rise to puerperal mania; we shall now view the effects of hæmorrhage as they are met with uncombined with the conditions previously alluded to. This condition of system has been called by the French pathologists a state of anæmia, and is characterised by a pallid condition of the skin; great nervous excitability; a throbbing of the temples; vertigo; tinnitus aurium; a frequent, jerking, compressible pulse; a great tendency to faint on the slightest exertion, or in the upright position; palpitation of the heart; halitant respiration; and, generally, great thirst. The treatment to be adopted in anæmia from loss of blood, consists in maintaining a perfect quiet of mind and body, in a free exposure of the patient to fresh air, a mild but nutritive diet, and a regular but not an over-active state of the bowels. The symptoms we have just enumerated as arising from loss of blood are sometimes met with, in a mitigated form, at a much later period of the puerperal state, and arise from the drain occasioned by superlactation. The treatment of these cases is more simple, and consists generally in the weaning of the child, the adoption of a more nutritive diet, and change of air. With respect to what are called milk-abscesses, they arise from the inflammation consequent on over-distention of the lactiferous tubes, and require the same mode of treatment as is adopted in abscess when it occurs in other parts than the breast. [ABSCESS.] They are best prevented by permitting the infant to suck within a few hours after delivery, and by repeating this act frequently. When the secretion of milk is excessive, the bowels should be kept freely open by saline purgatives.

PULLEY. A machine used in the arts for the purpose of transmitting power, which consists of a case with one or more openings, in which a similar number of sheaves revolve upon an axle; the case or block is surrounded in the direction of its length by a band ending in a hook able to be fixed to any point of support. The cord or chain working upon the sheaf, or sheaves, either increases the power exercised, whilst it decreases the velocity of movement, according to the principles of mechanics; or it simply changes the direction of the movement transmitted. Pulleys are either made of wood, or of metal: the former being almost exclusively used for ship-building. In the wooden pulleys the blocks are usually made of elm, the sheaves of lignum vitæ, and the axles of either wood, or of iron; in metal pulleys the blocks are made of iron, the sheaves of brass, the axles of iron or of steel, and the bushes of brass. The proportions of the various parts of a pulley are regulated by the width of the sheaf, and this module itself must be chosen so that the cord or chain shall ride easily on its gorge, without working against the sides; the proportion of the diameter of the axle to that of the pulley must be made as small as is consistent with the strength of the machine, and the sheaves must be so truly bored as to allow of their revolution without any friction against the sides of the blocks.

The term pulley is likewise applied to some of the narrow band wheels used for the purpose of driving machinery gearing, especially when they are of the description technically known under the name of fast and loose pulleys, or those in which one of the assemblage of wheels is made to revolve freely upon the shaft, without being able to communicate any motion to the latter. In these cases the velocity of the axle driven by the intervention of the pulley will be regulated by the proportions between the diameters of the pulleys. [MACHINE.]

PULMONIC ACID. Synonymous with PNEUMIC ACID.

PULPIT. This term affords a striking instance of the great change of meaning and application which words frequently undergo, for, exclusively of the Latin termination, it is identical with *Pulpitum*, which signified that part of the Roman stage (distinguished from the orchestra) on which the actors recited and performed their parts. The French *pupitre* and the English *pulpit* both come from the same source, but are dissimilar in signification; the former meaning merely a reading-desk, and *chaire* (*cathedra*) being the term that corresponds with our English pulpit. The *ambo* of the early Christians appears to have been different both in form and purpose from pulpits afterwards used for preaching, it being rather a low platform on which parts of the service were sung or recited. The most ancient pulpits now existing are supposed to be those in S. Lorenzo fuor delle Mura and S. Clemente at Rome; and these and other early pulpits of the same kind are of marble, with inlaid or mosaic compartments. In the church of S. Lorenzo at Florence, and several other modern basilicas, there are two pulpits, one on each side of the nave. Great cost both of material and workmanship was frequently bestowed on pulpits; and some of them rank among the most celebrated monuments of art of their period. The pulpit in the baptistery of Pisa, by Niccola, is hexagonal, and supported on seven columns, one at each angle and a central one. Giovanni Pisano executed that in the nave of the Duomo at Pisa, besides which there are two others in the same church, on the opposite sides of the choir. The *Pergamo* of Santa Croce at Florence, by B. da Majano, is greatly extolled by Vasari for the beauty of its reliefs and sculptures. The two *pergami* in S. Lorenzo at Florence, are the work of Donatello; and of the mastery of composition displayed in their reliefs some idea may be formed from the specimen given of them in Cicognara's 'Storia della Scultura.' Notwithstanding the richness of such pulpits, and their elaborate execution, their general forms are not always the most pleasing or appropriate.]

For a long time the pulpit appears to have been treated as an architectural feature, being constructed, if not of marble, of the same material as the rest of the interior. Among numerous other examples of Gothic stone-pulpits may be mentioned one that has been much admired, though it is very impure in style, in the nave of Strasburg cathedral. One of the most celebrated as a performance of art is the magnificent oak pulpit in the nave of St. Gudule, at Brussels; the whole is elaborately carved, and the pulpit itself is supported by figures representing Adam and Eve expelled from Paradise.

Of stone-pulpits we have only a few remaining in this country; but there is one in Bristol cathedral dated 1624, another in Worcester, drawings and details of which latter are given in Pugin's 'Gothic Specimens;' and others in Huish-Episcopi, Somersetshire; Coombe, Oxfordshire, &c.; but old carved wooden pulpits are much more common. The Worcester pulpit, and a stone pulpit in the outer court of Magdalene College, Oxford, are instances of what may be termed *oriel pulpits*, being made to project after the fashion of an oriel, from a pier or wall, and similarly corbelled below, instead of being supported from the ground. Another, still more ancient and curious—and we may add, more beautiful—is that at Beaulieu, Hants, which projects from an elegant open Gothic arch, and is supported, not on a corbelled and moulded oriel-stool, but on a short reversed spire, whose angles are decorated with small pillar-shafts, and the sides between them with foliage. Besides pulpits of this kind in the courts and cloisters of religious houses, there were others called *preaching-crosses*, from which sermons were delivered in the open air: Paul's Cross is a celebrated and well-known instance.

PUMP. A machine used in the arts, and in the ordinary business of life, for the purpose of raising water from a lower to a higher level; or for the purpose of forcing it through pipes to be distributed as may be required. Pumps are occasionally used in similar manner, in dealing with other aqueous fluids, with trifling modifications in their details, according to the nature of the fluids; and a peculiar class of pump is employed for the purpose of either removing, or of distributing air or other gaseous fluids. The general principles of the pumps applicable to the respective kinds of fluids, are however so closely allied, that it may suffice here to notice only the more common descriptions of *water* and of *air-pumps*, referring occasionally to some of the most important modifications to which they are subjected in order to adapt them to particular circumstances.

Water pumps are divided into two general classes, called 1st, *suction pumps*, or 2nd, *forcing pumps*, according to their mode of action. The suction pumps are those in which the atmospheric pressure is made use of to force a column of water to rise in a tube, from which the air has been withdrawn in such a manner as to leave a vacuum in its interior. The forcing pumps are those in which a mechanical effort is applied to the water to raise it to the required level. Evidently the power of the suction pump is limited in this respect; namely, that the column of water cannot rise beyond the level at which the weight of the column of water balances the weight of the atmosphere; whereas the power of the forcing pump is only limited by the dynamical effort employed, and by the strength of the machinery itself. Suction pumps are therefore only used in simple cases, and where the water has not to be raised to any great height; at times, combined suction and forcing pumps are used, but wherever large volumes of water have to be moved, forcing pumps are the only ones which are habitually employed. The common lifting pumps are, it may be added, simply those modifications of the forcing pumps, which are used in cases where the quantity of water to be raised is not very great, or where the height above the limit of action of the suction pump is not very considerable.

The component parts of all kinds of pumps are, 1°, the cylinder in which works, 2°, the piston; 3°, the suction, or feed-pipe; 4°, the various clacks or valves; and 5°, the delivery pipe. In the large pumping works for town supplies, there are placed upon the delivery pipes either some air vessels, or some stand pipes or water towers, for the purpose of equalising the pressure on the distributing pipes, and of obviating the hydraulic jar produced by the alternate motion of the piston in its up and down strokes. The motive power used in working the pumps, and the various details of the pipes, pistons, piston-rods, valves, &c., are so numerous that it will only be possible here to describe some of the most important modifications of them.

The cylinder is usually circular in its transverse section, although in some cases it is made quadrangular, or even polygonal. For small lifts it may be made either of wood or of metal; but the former material wears away too rapidly for works destined to be used for any length of time. The use of wooden pumps is, therefore, almost exclusively confined to agricultural purposes, or to ships, principally on account of their economy in the first instance; whilst cast-iron or brass, is almost exclusively used for the cylinders of pumps employed in industrial operations. Of whatever material the cylinder may be made, it is, however, essential that it should be perfectly straight and true in its bore; even when the piston does not work in close contact with it. The power of a pump, of whatsoever description it may be, depends upon the inner diameter of the cylinder. It is considered to be small, when the diameter is less than from 5 to 6 inches; it is considered to be large when it exceeds 1 foot in diameter; and it is only in the great mining operations, or in municipal water supplies that the diameter of pump cylinders exceeds 2 feet. The length of the cylinder only exceeds that of the stroke of the piston by a small quantity.

The piston is the most important part of the machinery of a pump; it is the part which requires the greatest skill in its manufacture, and upon whose correct action the success of the whole machine depends; under these circumstances, as might have been expected, it has been modified in the greatest possible variety of manners. If the piston raise the water during its ascent, or its descent only, its action is said to be *single;* if on the contrary, it should raise the water by both those motions, the action is said to be *double.* The ordinary suction pumps have wooden pistons, working hermetically against the sides of the cylinder, but bearing a clack in the centre, through which the water rises on the down stroke, to be lifted on the up stroke to the point of discharge. A more complicated description of piston for the purpose of raising the water on the up stroke is used in the lifting pumps, and they have to support the weight of the column of water above them. In the ordinary forcing pump, however, the piston only forces the water forward on the down stroke; but in the double action forcing pumps, the water is raised by both the up and the down strokes, by a peculiar arrangement of the clacks and delivery pipes, to be noticed hereafter.

Fig. 1.

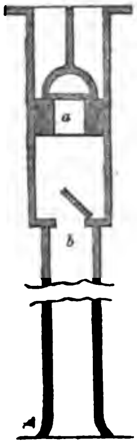
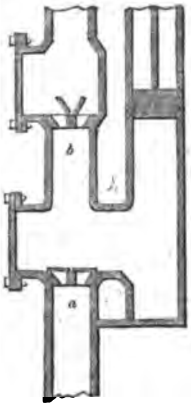


Fig. 2.



The pistons of common pumps are made ordinarily of a piece of hornbeam, to which the rod is attached by a kind of stirrup-handle, and which is pierced by a circular opening, *a* (*fig.* 1), whose diameter is equal to about half that of the piston. In the simpler forms of the suction and forcing pumps, the piston is made solid, and the water raised into the barrel or cylinder by the up stroke of the piston is forced on the down stroke to pass through a foot-valve placed upon the rising pipe fixed by the side of the cylinder, *b* (*fig.* 1); there is a valve also placed at the top of the arrival pipe, and both these valves are made so as only to open upwards. Under whatsoever circumstances the pistons may work, they are made to fit closely against the sides of the cylinder, by means of a species of packing, in order to cut off any connection between the air above and below them; but of course, whilst thus excluding the passage of air, they must not give rise to such an amount of friction as to cause any serious waste of labour in pumping. The packing may consist either of leather, spun-yarn, or of some anti-friction metal, acted upon by an internal spring.

The valves of pumps are known under the names of clack-valves, or of spindle-valves. The former are in fact flat plates of wood, metal, or leather, working on a hinge in only one direction, *a* and *b* (*figs.* 2 and 3), fitting closely upon the seating or face of the valve, and sufficiently stiff to resist deformation by the weight above them. The latter are either portions of cones, or small globes kept in their positions by means of spindles traversing their axes; upon the spindle a stop is placed to regulate the dimensions of the passage way. There are, however, some modifications of the spindle-valves, in which lateral guides are substituted for the central spindle, so that perhaps the term *seat*-valves would be more generally applicable to the class; and in the pumping-engines on the Cornish system a very complicated system of machinery is introduced, under the name of the equilibrium-valves, to regulate the admission of steam to the cylinders. The consideration of these steam valves hardly comes under this portion of our subject, but it has been thought necessary to allude to them in passing, as being connected with pumping machinery. When very foul water has to be pumped, or when a very heavy column of water has to be raised, there are also introduced some special forms of valves, such as the ball-and-socket valves, &c., *a* (*fig.* 4), which it would be impossible to describe in detail. It may suffice here simply to add that, inasmuch as the valves are precisely the portions of a pump which are the most likely to get out of repair, it is essential that means should be provided for obtaining easy access to them. This is usually effected by swelling out the pipes immediately above them, and by placing a moveable cover over the increased space thus enclosed.

Fig. 3.

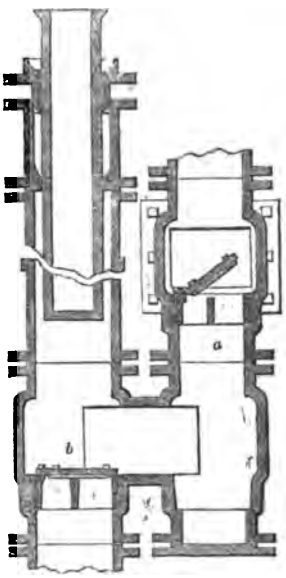
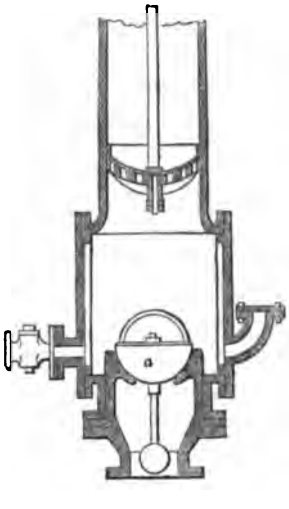


Fig. 4.



The suction and rising mains do not require any special description; for all that is required in the former, in addition to the ordinary conditions of pipes, is, that they should have some provision made at their lower end for keeping out large extraneous substances, and that the valve-seats and chambers of the upper end should be provided for. In the rising mains, the junction pieces, the valve-seats, and the delivery cisterns, are the only portions which require special castings. The suction pipes can rarely be made of more than 26 feet in length, and their diameter should not exceed more than $\frac{2}{3}$ or $\frac{1}{2}$ of that of the cylinder, without however falling below the latter dimension. The diameter of the ascending main should bear about the same proportions; its length need only be regulated by the power able to be applied to it; in some mines, ascending pipes of 750 feet in length are used.

In D'Aubuisson's admirable treatise, 'De l'Hydraulique,' the reader will find (at page 511, edition of Paris, 1840), the various conditions of the respective kinds of pumping machinery discussed in the most elaborate and philosophical manner. In this cursory notice it may suffice to state that D'Aubuisson shows that an ordinary suction pump cannot work efficiently at a greater distance, measuring from the underside of the piston to the surface of the water at the lower level, than 12 *b*, in which expression *b* will equal the height of the barometer at the place observed. This distance will vary between 30 feet and 26 feet 8 inches, according to the elevation; but the effective height will be further diminished by the interval between the bottom of the stroke and the foot valve; the interval in question should be made as little as possible, and should not exceed one-tenth of the diameter of the cylinder.

There is in all descriptions of pumps a certain amount of power required to be exerted, in addition to that which is necessary to raise the quantity of water to be delivered. In an ordinary suction pump this additional power is, on the ascending stroke, composed of the weight of the water above the piston, of the weight of the piston itself, and of the friction of the various parts. D'Aubuisson calculates that, in well-made pumps, the sum of these elements is equal to about $\frac{1}{12}$th more than the real statical weight resting on the piston. On the descending stroke the piston meets with a resistance arising from the contraction of the fluid vein, when the water passes through the clacks, and from the friction of the packing against the sides of the cylinders; as this resistance is, however, considerably less than that which is overcome on the ascending stroke, little attention is paid to it. In cases where large quantities of water have to be raised by pumps of this description, it is customary to couple them, in order to equalise the power exercised during the upward and downward strokes, by making the motions of the respective pistons reciprocally alternating. The two pumps pour their water into the same head, which thus gives nearly a constant discharge.

The resistances involving loss of power are much more numerous and more complicated in the case of force pumps, for in them not only is the whole column of water to be set in motion, but there is a loss of useful effect: 1st, in consequence of the contraction of the fluid vein at the foot valves; 2nd, in consequence of the bends, or changes of direction in the line of flow; 3rd, in the weight and friction of the valves; 4th, in the friction of the pumping machinery; and 5th, in the friction of the ascending column of water against the sides of the pipes, and in the inertia of the water itself. D'Aubuisson gives the formulæ usually adopted to calculate the value of these resistances (pp. 519 to 525); but he prefaces them by saying, that it is impossible to determine them rigorously. It may then suffice to say, that in some mining-pumps, where the lift is very great, the sum of these resistances is such as to reduce the useful effect of the pumping machinery to about one-half of the power exercised. In large force pumps the pistons are usually made of the description known technically by the name of *plungers;* that is to say, they are formed of hollow metal cylinders working in a stuffing-box, but with a small annular space between their sides, and those of the cylinders. Theoretically, the quantity of water raised by each stroke of the plunger would be equal to its sectional area multiplied by the length of the stroke, but in practice there is found to be a considerable loss of effect; and in cases where plunger pumps are used in conjunction with lifting pumps (as in deep mines), it is customary to make the former of $\frac{1}{12}$th larger diameter than the latter. In the force-pumps of very deep mines it is necessary to counterbalance the weight of the piston-rods, and to take great precautions to prevent their becoming bent under the jars they are exposed to by their own vibration.

The action even of connected pumps being of necessity of an intermittent character, there is introduced near the point of delivery a large vessel, called the *air vessel,* into which the water is forced in greater quantities than can be discharged by the outlet valve, during the period of inlet. The water then accumulates in the air vessel, and compresses the air contained in it, sometimes even to the extent of producing a pressure equal to three atmospheres. Of course when the water ceases to enter through the valve connected with the piston, the reaction of the compressed air maintains the discharge through the foot valve, and thus the discharge is rendered almost continuous. The air-vessels also diminish in a notable manner the hydraulic jar on the rising main, produced by the intermittent action of the pumping machinery.

In addition to the suction and forcing pumps, there are several descriptions of machines used for raising water, such as the chain pumps, norias, Archimedian screws, scoops, bucket wheels, Persian wheels, flash wheels, rotary pumps, &c.; and perhaps it would be preferable at once to notice them, even though in some cases the machinery can hardly be considered to come under the strict definition of the word "pump." Thus, the chain pump consists of a series of flat boards which are attached to an endless chain, and the latter works upon fixed wheels at the top and bottom of the course; the flat boards in ascending pass through a cylinder, and lift in it a column of water. The Noria is a machine much used in the East for irrigation purposes, and consists of a series of earthen pots ranged upon a rope, working also on fixed wheels; so that the pots dip into, and raise the water from the bottom of the well, to discharge it when they pass over the top wheel. The Archimedian screws, as their name implies, consist of a series of threads, or worms, fixed upon an axis of rotation bearing on a fixed pivot at the lower end, and having a winch handle at the top. There are usually three threads working in a species of close fitting race, or channel, open at the top; the diameter of the thread is usually made from 13 to 26 inches, but occasionally it has been made as much as 6 feet; the angle made by the thread with the axis of the central shaft (which, it may be added, is usually equal in diameter to $\frac{1}{3}$rd of that of the thread) varies between 45° and 78°; but in practice an angle of 60° is found to be the most advantageous. The axis of the central shaft is usually placed so as to form an angle of from 30° to 45° with the horizontal line. These Archimedian screws are much used in Holland for drainage works; they are driven by wind-mills, and raise the water very economically, provided the lift be not more than 15 feet. On the Sambre and Meuse canal a screw of 5 feet 4 inches diameter, and 21 feet 6 inches lift, worked by a steam engine, has given very satisfactory results.

The scoops are, in fact, large troughs fixed at one end on an axis, and connected at the other to a balance beam, to which an alternate motion is communicated from some extraneous motive power; so that the scoop is made to dip into the water when the beam is at its lowest point, and to discharge the water over the line of its own fixed axis when the beam rises. These engines are applicable to lifts of from 12 to 15 feet, and they certainly work with very economical results. The bucket wheels are, in principle, very similar to the norias, and are used in Switzerland, and in some parts of Germany, for irrigation purposes; they consist of a number of small buckets, arranged on the periphery of a wheel made to revolve in water, so that the buckets become filled at the bottom of the revolution, and discharge their contents at the top of the same. The dynamical results of these wheels is not very satisfactory, but they do not require frequent repairs, nor do they require attendance; conditions which make them desirable for the class of work they are usually applied to. Persian wheels have been occasionally used for raising water from the interiors of coffer-dams, but are now almost entirely abandoned; they consist of a series of helicoidal channels formed in large wheels, which are made to dip in the water, and as the wheel revolves the water finds its way to the centre of the wheel, where an outlet is provided for it. It is very rarely that the lift of these wheels exceeds 12 feet. The dash wheels are, however, the machines of this description of the most common use, and in the polders of Holland they may be seen in almost every direction in connection with windmills, whilst in our own fens they are as frequently employed with steam as a motive power. They consist of a series of floats fixed on the periphery of a wheel made to revolve in the water with great velocity, and the tangential force thus applied to the water itself is sufficient to raise it to a height of nearly 20 feet. There is a very efficient wheel of this description at work in the Deeping Fen, near Spalding, set in motion by a steam engine of 80-horse power; the wheel is 28 feet in diameter, with floats measuring $5\frac{1}{2}$ feet by 5 feet, moving with a velocity of 6 feet per second on the average; the quantity of water discharged is 165 cubic feet per second, raised 5 feet. At Ten-mile bank, near Littleport, in the Isle of Ely, there is a wheel of 40 feet in diameter also moved by steam.

The Rotary, or Centrifugal, pumps are those in which a rectilineal vertical motion is communicated to the water to be raised, by means of a wheel, bearing a series of fixed arms rotating at a high velocity in a close drum, and receiving its supply through the apertures in the side of the drum close to the axis. The shape of the arms has a very material influence upon the useful effects of these pumps; and, after many experiments, it has been found that the most advantageous form to be given to them is to curve them backwards to the direction of the movement, so as to form a tangent to the circumference of the wheel at the points where they intersect it. Amongst the most valuable forms of these centrifugal pumps for drainage purposes, those manufactured by Mr. Appold, or by Messrs. Gwynne and Co., are those most generally known; and perhaps it may be desirable to add that the latter work with the smallest loss of power compared to the useful effect with small lifts: Appold's pumps, however, present more satisfactory results when higher lifts are required. All these engines are inferior to the best forms of force-pumps when large volumes of water have to be raised to great heights; and their use would appear, in their present forms at least, to be most advantageously limited to lifts of about 30 or 40 feet vertical as a maximum.

The discussion of the motive powers to be applied for the raising of water by pumps, or other machines, will be more conveniently reserved to WATER SUPPLY.

In Air-Pumps the objects to be obtained are twofold:—1st, to exhaust the air under a receiver, for the sake of obtaining a vacuum; and 2nd, to condense the air so as to produce an increased pressure upon the enclosed surface. The former object is sought to be obtained in philosophical experiments, or in chemical or physical investigations; the condensation of air has lately been applied to many important operations in the arts of construction. The exhaustion of the air is effected by means of one or more pistons working through air-tight cylinders, and provided with a series of valves which allow the air to pass from the receiver to the exterior, but without admitting any return; so that the air of the interior becomes more and more rarified in proportion to the effort employed, and the perfection of the machinery. No instrument of this description has yet secured a perfect vacuum, though from what has been said in the article AIR-PUMP, some remarkable results seem to have been attained, approximating very closely to that condition. As the mechanism of air-pumps for exhaustion has been described in the article thus referred to, it will suffice here to state that in machinery they are principally used for the purpose of overcoming the resistance opposed by the steam left in the cylinders of steam engines, and for removing the contaminated air in mines, or in diving-bells. The condensing air-pumps, in their turn, are made with valves opening inwards only, so as to allow air to be forced into the receiver without being able to return. They are employed for the purpose of forcing air into diving-bells, into blowing machinery of mines, and latterly into the cylinders used for making the foundations of bridges upon running sands. In the latter case the compression of the air reaches to the extent of an effort equal to at least three atmospheres, and the workmen are obliged to carry on their operations in a medium of that density. A description of the machinery of this description used in the Rochester bridge, was given some years since by Mr. Hughes, who executed the works of that remarkable monument; and the system has since been applied with success in the cases of the bridges of Kiel over the Rhine, and of the railway bridge over the Theiss in Hungary. Coulomb appears to have been the first person to introduce this system in a *mémoire* addressed to the Academie des Sciences in 1778; and the French engineers have since that period frequently employed it in hydraulic, or in mining operations, when the pressure to be overcome has not exceeded the above quoted limit of three atmospheres.

Ships' Pumps.—For a number of years the chain-pump, consisting of a series of metallic discs, regularly arranged upon a bar chain, each disc acting as a piston, was the only one in use on board large ships, and it may still be seen in several of our sea-going old line-of-battle ships, although new chain-pumps are no longer fitted in her Majesty's service.

Pumps of various descriptions are in use both in the navy and merchant service—each form having its qualifications. That much is required from them may be gathered from the fact that a steamer of moderate size requires a ton and a quarter of condensing water per hour for each horse power; and therefore in case of serious leak it is of vital importance to obtain this quantity for injection into the boilers from the hold of the ship by means of the engine itself. Her Majesty's ship Phœnix not long since was saved from foundering in the Bay of Biscay, by thus injecting from the bilge; but had the injection pipe been unprotected from chips, &c., the ship's pump alone could not have saved her.

The following may be considered to be the necessary qualifications of a ship's pump, namely, it should be 1, easy to work; 2, give a continuous stream of water of the greatest possible quantity; 3, be not easy to choke; 4, be so simple in construction as to be easily taken to pieces, and repaired at sea; 5, the valves should be of durable material; 6, so constructed as in case of choking to admit of the ready removal of the bottom box without withdrawing the piston or pistons.

Among the best pumps in use at sea, may be mentioned Massey's double action; Dowton's many-pistoned; Robertson's double action twin pump; Redpath's pump; Suffield's india rubber valved pump, &c. From among these, on account of its very peculiar construction, and from its having been recently tried successfully against several other forms of pumps on board her Majesty's ship Fisgard, we give below an illustration of Redpath's, of Limehouse.

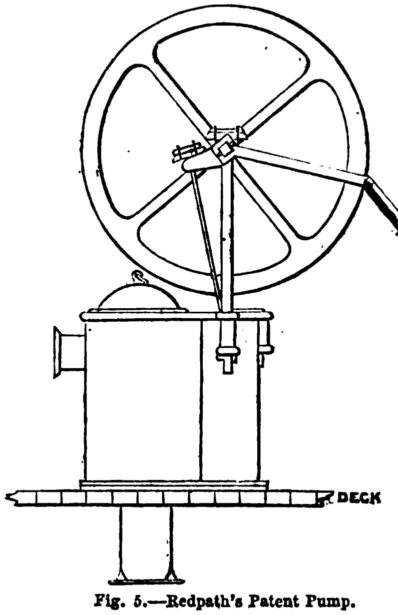


Fig. 5.—Redpath's Patent Pump.

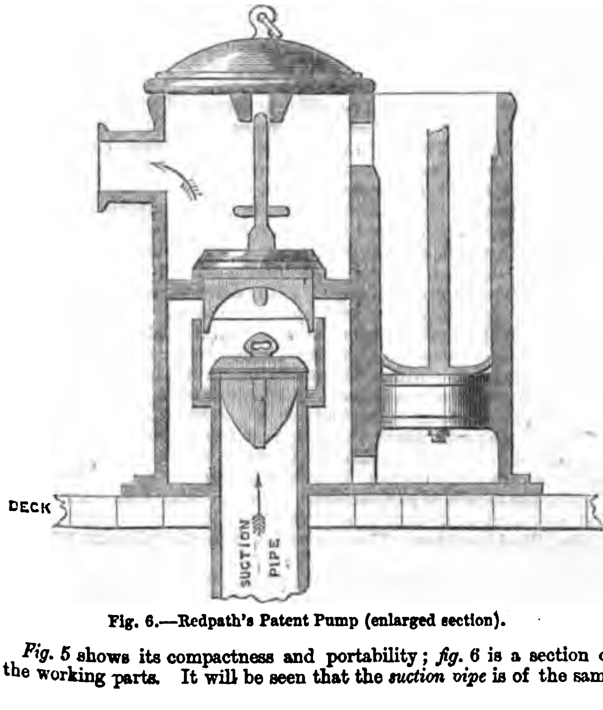


Fig. 6.—Redpath's Patent Pump (enlarged section).

Fig. 5 shows its compactness and portability; *fig.* 6 is a section of the working parts. It will be seen that the *suction pipe* is of the same area as the bottom valve, so that considerable friction and therefore labour are thus saved; and the bottom valve, like the upper valve, requires no fixing: both valves being made wholly of metal they *drop* into their places—it is therefore scarcely possible for them to get out of order.

The whole is exceedingly simple, and whereas at the trial in the Fisgard the other pumps occupied about seven minutes in taking apart and being replaced into working order; Redpath's was done in about half a minute (a valuable qualification in a leaky ship). This pump has no leather buckets nor bottom boxes, but the bottom *valve* is so placed that should any accumulation of sand, tar, oakum, chips, or shingle occur, if they are too large for the pumps to deliver, it is only the work of a few seconds to *lift* the valves in order to free them. Nearly 1000 of these pumps are afloat in British ships, and the simplicity of its action has obtained for it also a large sale in the American and other navies.

PUMPKIN is the vulgar name of the fruit of the *Cucurbita maxima*, a plant whose native country is not certainly known, but which is probably a variety of *C. pepo*, a species inhabiting the Levant. It is, as is well known, an annual plant, sending forth many long succulent angular rough shoots, bearing leaves and flowers something like those of the cucumber. Its fruit is often of enormous size, specimens having been produced in this country weighing 220 lbs., and in hotter countries they are still larger. This kind of fruit is however only furnished by the variety called the yellow Potiron; in other varieties it is much smaller. The seed of the pumpkin should be raised in a frame, in a garden-pot, after the same manner as the cucumber, and planted out upon a dunghill, or in any well-manured soil, as soon as the frosts are gone, beyond which it requires little or no care. The fruit, when ripe, is used for soup, or is baked with apples or pears as an ingredient in tarts. When young, it may also be boiled and brought to table like vegetable marrow.

PUN. A pun has been defined by Addison ('Spectator,' No. 61) to be "a conceit arising from the use of two words that agree in the sound but differ in the sense." Sometimes, however, the pun is effected by the employment of only one word, which is susceptible of a double application; as when one who had undertaken to pun upon any subject that should be given him, on being desired to make a pun on the king, answered that the king was no subject. Sometimes, too, the sound that is thus made to convey two ideas at once is not an entire word, but only a syllable. The definition, moreover, to be complete, ought to have explained in what the effect of the conceit consists. It appears to be, as we have just hinted, in the novelty and unexpectedness of the signification or application presented by the pun—a novelty which always at least produces surprise, and often the livelier titillation of a grotesque or otherwise ludicrous image.

A sketch of the history of puns has been given by Addison in a well-known paper in the 'Spectator' (No. 61), in which he traces the existence of the practice from the time of Aristotle downward. The figures of speech or turns of expression known among the Greeks by the names of the *paragramma* (παράγραμμα), and the *paronomasia* (παρωνομασία), the *antanaclasis* (ἀντανάκλασις), and the *plôke* (πλοκὴ), were often merely what we should now call puns. Addison observes that Aristotle, in the eleventh chapter of his 'Rhetoric,' describes different kinds of puns or paragrams, among the beauties of good writing, and produces instances of them out of some of the greatest authors in the Greek tongue. We may also refer to another very clever paper in the 'Guardian' (No. 36), attributed to a writer of the name of Birch, which contains what is called 'A Modest Apology for Punning.' In the introduction to this paper the distinction is happily enough drawn between the extemporaneous puns of conversation and the punning in deliberate and grave compositions, which in this country, in the early part of the 17th century, used to be reckoned eloquence and fine writing. "I look," says the author, "upon premeditated quibbles and puns committed to the press, as unpardonable crimes. There is as much difference betwixt these and the starts in common discourse as betwixt casual rencontres and murder with malice prepense."

PUNCH, the name of the principal character in a well-known puppet-show which is exhibited about the streets, and which appears to have originated in Italy. The name is a corruption of *Policinella*, the Neapolitan clown, who is generally the leading character in puppet-show performances. But the show itself, or rather the puppets, are styled by the Italians *Fantoccini*. Galiani, in his 'Vocabolario del Dialetto Napoletano,' ascribes the origin of *Policinella*, or rather *Polecenella*, as it is pronounced by the Neapolitans, to a company of strolling comedians, who, having met with a droll peasant named Puccio d'Aniello, at the town of Acerra, near Naples, engaged him to appear in his native character. By degrees personifications of the original Polecenella were multiplied all over the country. The character was made the medium of much witty satire, private and political, became the popular favourite with all Neapolitans, and thence spread elsewhere. It is noteworthy that the district in which Acerra is situated was remarkable in ancient times for that kind of dramatic wit and farcical humour which has made the reputation of the modern Polecenella. [ATELLANÆ FABULÆ.] Mr. Forsyth, indeed, thinks that the descent has been uninterrupted, and that the name has been derived from the nose, "a pulliceno pullicinello," a belief, he thinks, confirmed by an ancient bronze figure discovered in Rome, possessing the prominent feature which has ever been characteristic of Punch.

PUNCHING. [Chasing; Mint; Riveting.]

PUNCTUATION is the art of dividing written or printed composition into sentences and clauses, by points or stops, so as to indicate the closer or more remote connection of the several parts. It serves to elucidate the sense, and thus also assists the delivery, since the latter must have reference to the grammatical construction.

The elements of a system of punctuation are discoverable in ancient times. Aristotle mentions the subject in his 'Rhetoric' (iii. 5); Jerome, in the 4th century, attended to the punctuation of the sacred books which he revised; about the middle of the 5th century, Euthalius published an edition of the four Gospels, and afterwards of the Acts, and of all the apostolic Epistles, in which he divided the New Testament into *stichoi* (στίχοι), or lines, regulated by the sense, so that each terminated where some pause was made in the reading; and in the Alexandrine manuscript, which may be referred to the 4th or 5th century, we find not only a break at the end of each paragraph, but stops inserted, though sparingly, in the body of the sentences.

The invention of the modern system of punctuation has been attributed to Aristophanes, a grammarian of Alexandria; but the subject was very imperfectly understood till the close of the 15th century, when the learned Venetian printers, the Manutii, increased the number of the signs, and established some fixed rules which have been so generally adopted, that we may regard them as the inventors of the present system.

The points used in English composition are:—

The comma, marked thus	,	The period, or full stop	.
The semicolon	;	The note of interrogation	?
The colon	:	The note of admiration	!

to which may be added the dash —, the apostrophe ', and the parenthesis ( ).

It is considered that the proper length of the pause at a comma is while we may count *one;* at a semicolon, *two;* at a colon, *three;* and at a period, *four.* But it will be easy to show that there is frequently a much greater separation of the sense, and that there ought therefore to be a longer pause at some commas than at others. Thus in the following sentence there should evidently be a longer pause after *instance,* than after *candour, fortitude, charity,* and *generosity,* though these words are all followed by the same mark of grammatical punctuation, namely the comma: "The qualities of candour, fortitude, charity, and generosity, for instance, are not in their own nature virtues; and if ever they deserve the title, it is owing only to justice, which impels and directs them."

The form and structure of sentences are so various, that it would be difficult, if not impossible, to lay down rules for punctuation which shall meet every case which can occur. The following may serve as a general guide.

I. The *comma* is used,—

1. To throw together such similar parts of speech as are joined in pairs by the conjunction *and.*

2. To separate the several members of a series, that is, a succession of similar words or members.

3. To separate from the rest of the sentence such clauses as are added by way of explication or illustration, or such as are really parenthetical, though they may not be so marked.

4. To separate from the rest of the sentence words in the vocative case.

5. In many cases to separate the relative and the antecedent.

6. To separate from the rest of the sentence such clauses as are introduced by a connective, conditional, or exceptive particle, or by an adverb of time or place; and to separate antithetical clauses, and such comparative clauses as are introduced by the adjectives *like, better,* by the conjunctions *as, so, than,* by the adverbs *how much, more, oftener, rather,* unless the comparative member at the end be short.

II. The *semicolon* is used when a longer pause is required than at a comma, but when the sense is imperfect, and needs some other member to render it complete. Or it is used for dividing a compound sentence into two or more parts, which are not so closely connected as those which are separated by commas only, nor yet so independent and perfect as those which admit a colon: thus—

"Life, with a swift though insensible course, glides away; and like a river which undermines its banks, gradually impairs our state."

"As there is a worldly happiness which God perceives to be only disguised misery; as there are worldly honours which in his estimation are a reproach; so there is a worldly wisdom which in his sight is foolishness."

III. The *colon* may be inserted—

1. When a member of a sentence is complete in itself, but is followed by some additional remark or illustration of the subject: thus—

'Do not flatter yourself with the idea of enjoying perfect happiness: there is no such thing in the world."

"Keep close to thy business: it will keep thee from wickedness, poverty, and shame."

2. When several semicolons have preceded, and when a longer pause is necessary in order to mark the connecting or concluding sentiment: thus—

"A divine legislator uttering his voice from heaven; an almighty governor stretching forth his arm to punish or reward; informing us of perpetual rest prepared hereafter for the righteous, and of indignation and wrath awaiting the wicked: these are the considerations which overawe the world, which support integrity, and which check guilt."

3. A colon is generally placed at the close of the words which introduce an example, a quotation, a saying, a speech, or a narrative: thus—

"The Earl of Chatham made an excellent speech, from which the following is a brief extract: 'I know that the conquest of British America is an impossibility.'"

IV. The *period* or full stop is placed at the end of a sentence, that is, at the end of such an assemblage of words as present a complete and independent sense: thus—

"Truth is the basis of every virtue."

"The Latin tongue is now called a dead language, because it is not spoken as the mother tongue of any nation."

In some sentences an additional clause is included, which does not modify the preceding: thus—

"The law of the Lord is perfect, converting the soul."

These are called *loose sentences.*

V. The *note of interrogation,* as its name implies, is placed at the end of every question.

The Spaniards place this mark also *at the beginning* of interrogative sentences; and it must be acknowledged that in some cases this is an advantage, as it suggests to the reader from the first the tones of voice which are suitable.

VI. The *note of exclamation* or *admiration* is placed at the end of such words or clauses as express any strong passion or emotion of the mind.

The *dash* should be used sparingly: it is introduced with propriety where a sentence or dialogue breaks off abruptly; where the sense is suspended, and continued after a short interruption; where a significant pause is required; where there is an unexpected turn in the sentiment, or a sort of epigrammatic point; when a sentence consists of several clauses which form the nominative to a verb following, or lead to a conclusion or inference, and it is desirable to assist the eye more readily than by semicolons; and in some cases to indicate an ellipsis.

The *apostrophe* shows the omission of a letter, as in *form'd, e'en, e'er,* used chiefly in poetry; and in the genitive case, as *man's, boys',* both in prose and poetry.

The *parenthesis* marks a clause, which should contain some necessary information, or a useful remark, introduced into the body of a sentence *indirectly,* but which might be omitted without doing injury to the sense of the construction.

It has been remarked above, that one use of the points is as a guide to reading; but it must not be supposed that those which are usually inserted even in well punctuated books are sufficient for this purpose. But the pauses required in good and impressive reading or speaking belong to *elocution,* and will be found treated of under Oratory.

PUNICIN. A non-azotised, bitter, uncrystallisable substance of unknown composition found in the bark of the *Punica granatum.*

PUNISHMENT. The verb *to punish* (whence the noun substantive *punishment*) is formed from the French *punir,* derived from the Latin *punire,* anciently *poenire,* which is connected with *poena* and the Greek ποίνη. Poine signified a pecuniary satisfaction for an offence, similar to the *wehrgeld* of the German codes: *poena* had doubtless originally a similar sense; but in the Latin classical writers its meaning is equivalent to that of our word *punishment.*

Punishment may be inflicted on men by a supernatural being or by men; and it may be inflicted on them either in the present life, or in the existence which commences after death. Punishment may likewise be inflicted by men on the more intelligent and useful species of animals, such as horses and dogs. In the following remarks, we confine ourselves to punishment inflicted by man on man.

The original idea of punishment was, pain inflicted on or endured by a person as a satisfaction or atonement by him for some offence which he had committed. (Grimm, 'Deutsche Rechtsalterthümer.') According to this conception of punishment, it appeared to be just that a person should suffer the same amount of pain which he had inflicted on others by his offence; and hence the origin of the retaliatory principle of punishment, or the *lex talionis.* This principle is of great antiquity, and is probably the earliest idea which all nations have formed concerning the nature of punishment. It occurs among the early Greeks, and was attributed by them to their mythical prince and judge of Hades, Rhadamanthys. They embodied it in the following proverbial verse:—

εἴ κε πάθοι τά κ' ἔρεξε, δίκη κ' ἰθεῖα γένοιτο.
(Aristot., 'Eth. Nic.,' v. 8.)

The *talio* was also recognised in the Twelve Tables of Rome ('Inst.,' iv. 4, § 7), and upon it was founded the well-known provision of the Mosaic law, "an eye for an eye, and a tooth for a tooth:" a maxim which is condemned by the Christian morality. (Matth., v. 38–40;

and Michaelis, 'Commentaries on the Laws of Moses,' vol. iii., art. 240–2.)

The infliction of pain for the purpose of exacting a satisfaction for an offence committed is *vengeance*, and punishment inflicted for this purpose is *vindictive*.

By degrees it was perceived that the infliction of pain for a vindictive purpose is not consistent with justice and utility, or with the spirit of the Christian ethics; and that the proper end of punishment is not to avenge past, but to prevent future offences. (Blackstone's 'Commentaries,' vol. iv.)

This end can only be attained by inflicting pain on persons who have committed the offences; and as this effect is also produced by vindictive punishment, vindictive punishment incidentally tends to deter from the commission of offences. Hence Lord Bacon justly calls revenge a sort of wild justice.

But inasmuch as the proper end of punishment is to deter from the commission of offences, punishment inflicted on the vindictive principle often fails to produce the desired purpose, and moreover often involves the infliction of an unnecessary amount of pain. Again, the degree of the punishment will often be placed too high, if regard is had merely to the suffering produced by the offence in the individual case, or to the moral turpitude implied by it, and not to the facility or difficulty of prevention, or the mischievousness of the class of offences. All punishment is an evil, though a necessary one. The pain produced by the offence is one evil; the pain produced by the punishment is an additional evil; though the latter is necessary, in order to prevent the recurrence of the offence. Consequently a penal system ought to aim at economising pain, by diffusing the largest amount of salutary terror, and thereby deterring as much as possible from crimes, at the smallest expense of punishments actually inflicted; or (as the idea is concisely expressed by Cicero), "ut metus ad omnes, pœna ad paucos, perveniret." ('Pro Cluentio,' c. 46.)

It follows from what has been said, that it is essential to a punishment to be *painful*. Accordingly, all the known punishments have involved the infliction of pain by different means, as death, mutilation of the body, flogging or beating, privation of bodily liberty by confinement of various sorts, banishment, forced labour, privation of civil rights, pecuniary fine. The punishment of death is called *capital* punishment: other punishments are sometimes known by the name of *secondary* punishments. Moreover, the pain ought to be sufficiently great to deter persons from committing the offence, and not greater than is necessary for this purpose.

A punishment ought further to be, as far as the necessary defects of police and judicial procedure will permit, *certain*; and also, as far as the differences of human natures and circumstances will permit, *equal*.

If a punishment be painful, and the pain be of the proper amount, and if it be likewise tolerably equal and certain, it will be a good punishment.

The qualities just enumerated are those which it is most important that a punishment should possess. But it is sometimes thought desirable that a punishment should possess other qualities than those which we have enumerated.

1. Since the time when it has been generally understood that punishment ought not to be inflicted on a vindictive principle, the deterring principle of punishment (which necessarily involves an infliction of pain) has been sometimes overlooked, and it has been thought that the end of punishment is the reformation of the person punished. This view of the nature of punishment is erroneous in excluding the exemplary character of punishment, and thus limiting its effects to the persons who have committed the offence, instead of comprehending the much larger number of persons who may commit it. The reformation of convicts who are suffering their punishment is an object which ought to enter into a good penal system; but it is of subordinate importance as compared with the effect of the punishment in deterring unconvicted persons from committing similar offences.

2. It is likewise sometimes thought that punishment is inflicted for the purpose of getting rid of offenders, or of rendering them physically incapable of repeating their offence. Death has often been inflicted for this purpose; and bodily disablements of different sorts have been inflicted for the same end; transportation has likewise been often recommended on the ground of its getting rid of convicts. This view of punishment errs in the same manner as that just examined; inasmuch as it is confined to the persons who have actually committed offences. If all offenders were removed to a place of reward, they would be got rid of, but not punished. The principle of getting rid of the offender, or his confinement, for the purpose of protecting society against the known dangerous tendencies of a person, is properly applicable in the case of madmen.

A detailed account of the punishments which have been used in different nations may be found in different works on antiquities and law books. See, for the Greeks, Wachsmuth's 'Greek Antiquities,' vol. ii.; Hermann's 'Greek Antiquities,' § 139; for the Romans, Haubold's 'Lineamenta,' § 147; for the ancient Germans and for Europe generally in the middle ages, Grimm's 'Deutsche Rechtsalterthümer,' b. v., ch. 3; for modern France, 'Le Code Pénal,' liv. 1; and for England, Blackstone's 'Commentaries,' vol. iv.

The *Secondary Punishments* inflicted in this country are noticed under Crimes and Punishments and Penal Servitude.

An idle question is sometimes raised as to the right of a government to inflict death as a punishment for crimes, or, as it is also stated, as to the lawfulness of capital punishment. That a government has the power of inflicting capital punishment cannot be doubted; and in order to determine whether that power is rightfully exercised, it is necessary to consider whether its infliction is, on the whole, beneficial to the community. The following considerations may serve to determine this question respecting any given class of crimes. Death is unquestionably the most formidable of all punishments; the common sense of mankind, and the experience of all ages and countries, bear evidence to the truth of this remark. Moreover, capital punishment effectually gets rid of the convict. On the other hand, capital punishment, from its severity and consequent formidableness, is likely to become unpopular; and hence, from the unwillingness of judges and juries to convict for capital offences, and of governments to carry capital sentences into effect, uncertain. Whenever the infliction of capital punishments becomes uncertain, their efficacy ceases, and they ought to be mitigated. An uncertain punishment is not feared, and consequently the pain caused by its actual infliction is wasted. Capital punishments ought therefore to be pronounced only for crimes which could not be effectually prevented by a secondary punishment, and for which they are actually inflicted with as much constancy as the necessary defects of judicial procedure will allow.

PUPIL, ARTIFICIAL. The operation of forming an artificial aperture in the iris is required in a variety of cases in which the passage of light through the natural pupil to the deeper seated parts of the eye is obstructed; and to meet the different exigencies of these several cases various operations have been suggested, each of which in its turn deserves to be preferred. The chief of these are—1, the tearing away a portion of the iris from its attachment to the ciliary ligament [Eye], a method which is however now very rarely employed; 2, the making a simple incision through some part of the iris, by the retraction of whose edges an elliptical or circular aperture is produced; 3, the making a portion of the iris protrude through an aperture in the cornea, and cutting it off. In whatever way the operation be performed, it is necessary to make the aperture in the iris as large as possible, that when it contracts in the process of cicatrisation, it may not be too small to permit the passage of a sufficient quantity of light for useful vision.

PURCHASE, corrupted from the Latin Perquisitio, is defined by Littleton (i. 12) to be "the possession of lands or tenements that a man hath by his deed or agreement, unto which possession he cometh not by title of descent from any of his ancestors, or of his cousins (consanguinei), but by his own deed;" and thus comprehends all the modes of acquiring property in land otherwise than by descent. [Descent; Property.]

PURGATION. [Ordeal.]

PURGATORY ('a place of expiation,' from the Latin verb *purgare*, 'to cleanse') is the name given by Roman Catholics to an intermediate state of souls after death, and before the final judgment, during which they are supposed to expiate by certain punishments the guilt which they have incurred through life. Roman Catholic divines teach that it is only the souls of those who die in a state of repentance and in the communion of the church that are admitted into purgatory; those who die impenitent, or in a state of unbelief, are doomed to everlasting punishment. As for the duration of the term of expiation in purgatory, that is a matter which rests with divine justice, and varies according to the guilt of the parties, but Roman Catholics believe that the prayers of the living and other pious works may serve to shorten the term of souls in purgatory. This has given rise to the doctrine of indulgences, with which that of purgatory is closely connected. [Indulgence.] The Protestant and other churches which dissent from the church of Rome do not believe in purgatory. No mention of purgatory appears before the time of Augustine, who, in some of his works, speaks of it in terms not very explicit. The doctrine is said to have been first inculcated as a matter of belief by Gregory the Great, at the end of the 6th century.

PURITANS, a name first given in the reign of Queen Elizabeth to such clergymen of the Church of England as declined to subscribe to its liturgy, ceremonies, and discipline, according to the requirements of the bishops in their respective dioceses. Fuller assigns the origin of this name to the year 1564, and Strype to the year 1569; but it seems not very easy to ascertain the exact date when any such name might have been first used. The clergymen so called were advocates for a further reformation than the existing authorities deemed it proper to sanction; they desired a form of worship more simple and *pure* than they believed that to be of the church as then established. They were called Puritans probably out of derision, and the name was shortly applied to the laity as well as to the clergy. The Puritans were by other writers of the 17th century generally called non-conformists, a name first applied to men who objected to the clerical vestments about 1550. As Puritans they made a great figure in the Civil War against Charles I., but they very shortly separated into more definite sects, as Presbyterians, Baptists, &c. For a general history of the Puritans, the work of Neal, on the one hand, and, on the other hand, the works of Strype and Collier, may be consulted. On the political influence exercised by the Puritans, all histories of England contain detailed accounts. [DISSENTERS; NONCONFORMISTS.]

PURPLE OF CASSIUS. [GOLD.]

PURPURIC ACID. [URIC ACID.]

PURPURIN. [MADDER, COLOURING MATTERS OF.]

PURREE. [EUXANTHIC ACID.]

PURREIC ACID. [EUXANTHIC ACID.]

PURRENONE. [EUXANTHIC ACID.]

PURSER. [NAVY.]

PURVEYANCE (*purveance*, a providing), a prerogative formerly enjoyed by the king through the means of officers called purveyors, of purchasing provisions and other necessaries for the use of the royal household, and of employing horses and carriages in his service, in preference to all other persons, and without the consent of the owners. The parties whose property was thus taken were entitled to a recompense; but what they received was so inadequate, and so many abuses were committed under the pretext of purveyance, that it seems to have been always considered a most intolerable grievance. About forty statutes were passed upon the subject, many of them, like all the important early statutes, being a re-enactment of those preceding. Some of the most stringent occur in the 36th year of Edward III., and confining the exercise of it to the king and queen, (for it had frequently been asserted as their right by some of the great lords) provide that for the future "the heinous name of purveyor shall be changed into that of buyer;" forbid the use of force; and direct that where purveyors cannot agree upon the price, an appraisement shall be made, &c. &c. The provisions of these statutes appear to have wholly failed; and others were passed, but without effect. Several of the charges against Wolsey were the exercise of purveyance on his own behalf. (4 'Inst.' 93.)

In the time of Elizabeth, two attempts were made in the same year by the Commons to regulate the abuses of purveyance, at which the queen was extremely indignant. She seems to have employed this prerogative for the purpose of victualling her navy; but afterwards revoked the warrants, and designed to have taken away the commissions relating to the provision for her own household, some counties having agreed to furnish it at a certain rate, to get rid of the collectors—a kind of vermin which the queen called *harpies*. During the first parliament of James I., Bacon, on presenting a petition to the king, delivered his famous speech against purveyors, which forms a sort of compendium of the heavy charges made against them. Several negociations took place in that reign for the purchase of the prerogative of purveyance, but nothing was done. Under the commonwealth it fell into disuse, but was not formally abolished till after the restoration, by the statute 12 Ch. II., c. 24, the king receiving in lieu of it a certain amount payable on exciseable liquors. In the earlier periods of our history, purveyance was necessary for the support of the royal household; hence its continuance in spite of so many attempts to suppress it. Even after its final abolition several temporary statutes were passed, for its partial revival on the occasion of royal progresses. On behalf of the navy and ordnance, a statute to that effect occurs as late as 11 and 12 Will. 3. (Camden, 388; Bacon's 'Works,' vol. vi., p. 3, Montagu's edit.; Hume's 'Hist.'; 1 Bl. 'Com.', 287; 3 'Inst.', 82; 4 'Inst.', 273.)

PUS. [ABSCESS; INFLAMMATION.]

PUTREFACTION. When nitrogenous organic matters are exposed to air and moisture at a moderate temperature, they begin to combine with oxygen, and are said to undergo decay, being resolved gradually into carbonic acid, water and ammonia, or nitric acid. If such decaying matters be wholly immersed in water, they continue the changes which had commenced in air, at the expense of the oxygen of the water, which unites with carbon, hydrogen, and nitrogen as before, whilst the hydrogen of the water also unites with another portion of the carbon, forming light carburetted hydrogen—a gas known to be evolved from stagnant pools, and the presence of which in such cases is always a test of putrefaction. [EREMACAUSIS.]

PUTTY, the useful cement used by glaziers for fastening the glass in the frames of windows, is composed of linseed oil and whiting. The whiting should be well dried, and then pounded and sifted till it becomes a fine powder and is quite free from grit. The whiting, a little warm, should be gradually added to the oil, and well mixed by means of a piece of stick or a spatula. When it is sufficiently stiff, it should be well worked with the hand on a table, and afterwards beaten on a stone with a wooden mallet, till it becomes a soft, smooth, tenacious mass. Putty by exposure to the air gradually hardens till it becomes almost like stone. A ball of putty, when left some days, becomes somewhat hard, but may be easily softened by beating.

PUTTY POWDER is a pulverised oxide of tin, or of tin and lead, used in polishing. The metals are exposed to heat and to the admission of air in a furnace, or muffle of peculiar form; and the oxide is taken out in lumps about as hard as marble. The lumps are ground to powder under a runner, and the powder is sifted through lawn. The putty powder mostly used is an oxide of the mixed metal, or rather a mixture of two oxides, and is largely used as glass and marble polish, and as plate-powder. For the finer kinds of work, such as polishing lenses, the tin alone is used, without admixture with lead. The late Mr. Andrew Ross, the eminent optician, adopted a special mode, devised by himself, of making putty powder for polishing the exquisite lenses of his telescopes and microscopes. [TIN; METATANNIC ACID.]

PUZZUOLANO. [POZZUOLANO.]

PYÆMIA (pus in the blood), is a peculiar and dangerous state of the system, supposed to be produced by the introduction of pus into the blood. The symptoms connected with this state of the blood may occur in the course of other diseases, or they may come on without any previous attack of disease. The more characteristic symptoms are generally ushered in by more or less violent fits of shivering. When it is accompanied with any external suppurating surface, as is frequently the case, the discharge from this surface gradually dries up or becomes thinner and excessively fetid, and the wound assumes a flabby and unhealthy aspect. The patient becomes exceedingly languid and exhausted, and stupor or delirium comes on. The respiratory function is increased and the breath exhales a faint sickly odour. The lungs become congested, and the skin assumes gradually a yellowish tinge. Pains, with swelling, occur in the joints, and in the course of a little time effusion takes place in the synovial membrane and under the skin. The pulse is quick, tremulous, and rapid; the tongue, at first loaded with a yellowish fur, quickly becomes brown and dry, and the teeth and lips are covered with sordes. The abdomen becomes tender, and is frequently distended with flatus. The eye is dull, partial paralysis presents itself, the voice becomes feeble, and the patient sinks from the fourth to the tenth day from the first appearance of these symptoms.

After death the most conspicuous lesions are large accumulations of pus and puriform matter in the various parts of the body. These are found in the lungs, liver, spleen, brain, kidneys, heart, blood-vessels, pleura, joints, muscles, and the subcutaneous connective tissue. On examining the blood under the microscope, an increase in the white cells of the blood, which are not to be distinguished from pus-cells, has been observed. This, however, has not been observed in all cases; hence, perhaps, the impropriety of calling this disease by its present name.

The symptoms of this disease are generally the same as those which occur in inflammation of the veins or phlebitis. This state is again supposed to be identical with the disease occurring in puerperal women, and known by the name of phlegmasia dolens. [PUERPERAL DISEASES; VEINS, DISEASES OF.] The pathological state in which these symptoms come on has excited much discussion. Dr. Bennett gives the following:

1. That this condition is owing to an admixture of the blood with pus (pyohemia of Piorry), and that the pus corpuscles being larger than the coloured ones of blood, are arrested in the minute capillaries, and give rise to secondary abscesses.

2. That it is owing to the presence of any irritating body which cannot be eliminated from the economy, producing capillary phlebitis.

3. That it is dependent on a property possessed by pus of coagulating the blood.

4. That it is produced by the presence of a peculiar poison which contaminates the system.

The first view has been most generally held, but the fact that pus globules cannot be distinguished from the white cells of the blood would clearly indicate that they could not be retained in the capillaries as required by that theory. It is also found that in leucocythemia the blood is crowded with white cells without producing any of the above symptoms. Dr. Bennett also injected pus into the blood of an ass without producing any ill effects on the animal. These objections are also fatal to the second and third theories. The last view is that which is most consistent with the whole of the phenomena, and is alone applicable to those cases of pyæmia in which there is no wound or ulcerated surface, and no indication of the presence of pus cells in the blood. From the fact that this disease occurs where persons are exposed to poisonous exhalations from decomposing animal and vegetable matter from without, or to the absorption of decomposing animal secretions upon the body, it would appear that the blood becomes vitiated, and that the presence of pus cells in the blood, and depositions of pus in the various organs of the body, are but the results of this condition of the blood.

This disease is most frequently fatal, and each case requires to be treated according to the symptoms it presents. Local wounds must be attended to, and accumulations of pus should be removed by free incisions. The symptoms from the first indicate the necessity of stimulants, as wine and ammonia, and the introduction of nutritive and digestible food into the system. Quinine in large doses has been recommended.

PYIN. An albuminous substance contained in pus. Mulder considers it to be trioxyprotein.

PYRAMID (*πυραμίς*), a solid figure contained by a polygonal base and the triangles formed on the sides of the base by lines drawn from one point to the angles of the base. It is among plane solids what the cone is among curvilinear ones, and its solid content is one-third of that of a prism of the same base and altitude; that is, the number of square units in the base, multiplied by the number of linear units in the altitude, and the product divided by 3, gives the number of cubic units in the content.

The properties of a pyramid are important in the theory of PROJECTIONS, particularly the following:—Every quadrangular pyramid (or pyramid with a quadrangular base) has one section, and one only, which is a parallelogram. To find it, let the vertex be V, and let opposite sides of the base meet in A and B. Then every plane parallel to AVB cuts the pyramid in a parallelogram, one of whose angles is equal to the angle AVB.

PYRAMID, the term applied to elevated mounds of stone or brick-work of the geometrical shape of that name, the most remarkable of which are those in the plain of Gizeh, which were considered one of the seven wonders of the ancient world. The origin of the name is involved in much obscurity; but it appears, like obelisk, to be a Greek term, the hieroglyphic word for pyramid being *pa abmer*, *ben ben*, or *ber ber;* the Coptic *piharam*, and Arabic *el haram*, being derived from the Greek. These pyramids are sloped or symmetrical mounds placed over the graves or chambers of the sepulchres made for the monarchs and other great personages of the earliest Egyptian dynasties, commencing with the 3rd and ending with the 12th, after which their use was abandoned in Egypt. The pyramids lying in a vast plain or cemetery, extending from 29° to 30° N. lat., for between 60 and 70 miles, are supposed to be about 69 in number. They are all constructed in a uniform manner. A rectangular sepulchral chamber was first hollowed in the rock, with a passage of sufficient dimensions to admit the sarcophagus, communicating with the surface. Over this was at once erected a cubical course of masonry, which served for the nucleus of the pyramid. If the king died during the year, the masonry was covered with a polished casing in shape of a small pyramid; if the monarch survived, another course of masonry was added to the height of the nucleus, and the length of the lower stage or base increased by courses of stone on each side. Additions on the same plan continued to be made as long as the king lived, fresh courses being added from year to year. When the monarch died this ceased; the pyramid was cased by filling up the angles of the masonry with smaller stones, placing oblong blocks one upon another, so as to make a series of steps from the top to the base, and then bevelling off all these stones, commencing from the top downwards, at a uniform angle. A smooth surface was given to each side of the pyramid, rendering it a perfect triangle, while, owing to each stone overlapping the other, no vertical joint was left. Some differences are observable as to the manner in which the internal walls were either vertical or inclined; but the general principle is the same in all, and the mode of finishing the pyramid casings corresponds with the description of Herodotus (II. cxxv.). The means by which the stones were raised is not known; but the discovery of hemispherical holes about 8 inches in diameter, that look polished by the turning of a heavy body, have suggested the use of *derricks*, or similar machines—the employment of scaffolding for the purpose being impossible. All the pyramids are placed with their sides facing the four cardinal points of the compass, and their entrances are on the north side, somewhere about the centre. Extraordinary precautions were taken to prevent access to the sepulchral chambers; the passages, made exceedingly narrow, were closed by great blocks of stone or granite portcullises, which closed the passages before the apartment; and the entrance was not placed in the centre of the elevated masonry, where it could have been easily seen, but in the plain below.

The first group of pyramids is that of Memphis, the three principal of which are echelloned on an elevated plateau, 120 stadia from Memphis and 45 from the Nile. The largest of these—said by Herodotus to have been built by Cheops, by Diodorus attributed to Chembes or Chabryes, and by Manetho and Eratosthenes to Suphis or Saophis I.—formerly had a base 764 ft. square, which has been diminished, by the continual spoliation of the sides for material to build the city of Cairo, to 746 ft. Its ancient height, judging by the casing stones discovered by Colonel Howard Vyse, was 480 feet; its present is only 450. The angle of its inclination is 51° 50′. It is built upon the rock, which has been cut down at the sides to obtain a level platform; and its entrance, which lies 24 ft. 6 in. east of the centre of the north side, is 3 ft. 5½ in. broad by 3 ft. 11 in. high, with an incline of 26° 41′. This passage descends to the original sepulchral chamber of the pyramid, commonly called the subterraneous apartment, with a distance of 320 ft. 10 in. This apartment, which measures 46 ft. long by 27 ft. 1 in. wide, with a height of 11 ft. 6 in., has at its south end a horizontal passage of 52 ft. 9 in. long by 2 ft. 7 in. broad, and 2 ft. 8 in. high, leading south, apparently a continuation of the works in this direction for the purpose of forming a second sepulchral chamber for holding the furniture of the mummy; but the work was abandoned in this direction, because the prolonged life of the monarch caused the mouth of the passage in the rock to be covered by the masonry added to the body of the pyramid. At the distance of 63 ft. 2 in. from the entrance another passage of the same size was constructed at an angle of 26° 18′, and ran for 124 ft. 4 in. so slippery that the ascent was effected by small holes cut for the purpose, and then became a horizontal passage parallel to the plane of site of the pyramid, 109 ft. 11 in. long. Part of this passage is rather broader than the rest, and leads to a chamber commonly called the Queen's, having a groined roof, measuring 17 ft. by 18 ft. 9 in., and 20 ft. 3 in. high, having a recess at the east side, and placed nearly in the centre of the pyramid, at a distance of 67 ft. 4 in. from the floor or plane of site of the pyramid. This chamber was evidently made for the reception of the sarcophagus, but was subsequently abandoned, and the ascending passage continued on a larger scale with granite blocks 28 ft. high and 150 ft. 10 in. long, with a short horizontal passage leading to the upper or so-called King's chamber. In this short passage was a portcullis 12 ft. 5 in. high, to defend any entrance into the chamber. The King's chamber had a flat roof, and measures 17 ft. 1 in. by 34 ft. 3 in., with a height of 19 ft. 1 in., and the north side is more than 16 ft. 3 in. south of the pyramid, probably because the monarch was expected to survive so long as to admit of sufficient masonry being added to enable it to be placed there. As the heat and confinement of this chamber appears to have been stifling, two air-channels, one 9½ in. by 9 in., the other 9⅛ in by 8⅞ in., ran from the chamber to the north and south faces of the pyramid: these, when opened by Mr. Perring in 1837, restored the ventilation to the chamber. In the chamber itself is a sarcophagus of red granite, 7 ft. 6½ in. long by 3 ft. 3 in. broad, and 3 ft. 5 in. high without its cover, entirely plain, and neither ornamented with sculpture or inscriptions. This no doubt anciently contained a wooden coffin, in which was deposited the body of the founder; but both have disappeared long since, when the pyramid was opened and plundered. The King's chamber is surmounted by five other small chambers placed above, the uppermost having a pointed roof formed by stones placed *en décharge*. The object of these chambers appears to have been to lighten the roof of the apartment, which is flat, from the weight of the superincumbent mass. These chambers are from 37 ft. to 38 ft. 4 in. long, and from 16 ft. 4 in. to 20 ft. 6 in. wide. The height varies from 1 ft. 4 in. to 8 ft. 7 in., and they rise for 69 ft. 3 in. from the roof of the great chamber. The first of these nearest that point was discovered by Davison in 1764, the others by Colonel Howard Vyse in 1837, who named them Wellington, Nelson, Arbuthnot, and Campbell chambers; but they are generally called the chambers of construction, as showing the purpose for which they were made.

The opening of these chambers solved the enigma of the pyramid; their floors and roofs were made by blocks of red or syenitic granite from the quarries of Assouan, but the sides were partly formed by blocks of a hard calcareous stone, brought from the quarries of Mokattam and Tourah. While yet in the quarries the workmen had scrawled upon them in large linear hieroglyphics, in a red colour, the names and royal titles of two kings, accompanied by other words. Those in the so-called Nelson chamber, nearest the king's chamber, had only the standard name of Khufu, or Cheops; those in the Arbuthnot chamber the standard name, titles, and cartouche of Khnum Khufu; and those in the uppermost chamber, the titles and cartouche of Khufu, or Cheops, and hieroglyphs with numerals. Although an attempt has been made to show that these are two different monarchs, yet the fact of both having the same Horus or standard name at this epoch, shows that both names belong only to one monarch, the Khufu of the hieroglyphs and Cheops of Herodotus, whose body anciently reposed in the sarcophagus of the sepulchral chamber beneath. These quarry marks were placed in all sorts of ways in the chamber, and sometimes had been cut short by the sawing of the blocks of stone, showing that they were inscribed while the material was in the quarries. At the junction of the two inclined passages is the so-called well, consisting of a shaft 2 ft. 4 in. square, descending perpendicularly for 26 ft. 1 in., then 32 ft. 5 in. to a recess called the grotto, and finally for 133 ft. to the subterraneous apartment. It was cut through the masonry after it had been constructed, and therefore evidently did not form part of the original design, and is supposed to have been made for the workmen to descend after they had closed up the passage from the upper end of it. The base of this pyramid is about 137 ft. above the level of the inundation of the Nile; it contains at present 82,111,000 cubic feet of masonry, and anciently about 7,000,000 more, and the weight is calculated as 6,316,000 tons, covering at present 12 a. 3 r. 3 p. As it exists at present, stripped of its casing, there are 203 steps; they decrease, but not regularly, from the bottom to the top from 4 ft. 10 in. to 2 ft. 2 in., the stones being 9 ft. long, and 6½ ft. broad. The ascent is fatiguing, but not attended with danger, the summit having been often reached by ladies. The horizontal lines of the platforms are fitted with the greatest nicety, and joined by a cement of lime without sand. Some of the casing-stones at the base were discovered by Colonel Howard Vyse, and gave the angle of inclination. This pyramid is supposed to have been open at the Roman times, and traces of Latin inscriptions are said to have been found in the passages, as well as Cufic inscribed during the rule of the Arab conquerors of Egypt.

According to Herodotus the great pyramid was built by Cheops, who closed the temples, and stopped the sacrifices, and made a conscription of the people to build this monument by bringing the stone from the Tourah quarries; gangs of 100,000 men were relieved every three months; ten years were employed for the causeway, 3,000 ft. long, 60 ft. wide, 48 ft. high, which had a hieroglyphical inscription; the subterranean chamber, he states, was in an island made by a canal from the Nile; twenty more years were consumed for the masonry. It was constructed like steps, and the stones were raised from layer to layer by machines. He describes the manner of facing the pyramid from the top, and gives an account of a hieroglyphical inscription, recording 1600 talents of silver spent for the radishes and onions supplied to the workmen. Cheops reigned 50 years. Diodorus calls this monarch Chembes. At the time of Pliny the pyramids were then ascended, although the casing of the great pyramid is said to have remained till the Christian era. The pyramids in recent times have been visited and described by travellers since Belonius, A.D. 1553.

The second pyramid, called the pyramid of Cephren, was built by that monarch, who reigned, according to Herodotus, 56, and Manetho, 66, and the Canon of Turin gives the length of his life as 95 years. The base of this pyramid is elevated 33 ft. 2 in. above that of the great pyramid, or nearly 172 feet above the level of the high Nile. The ancient base measured 707 ft. 9 in., but it is now reduced to 690 ft. 9 in.; the height was formerly 454 ft. 3 in., but is now 447 ft. 6 in., the inclined was 572 ft. 6 in., now diminished by 9 ft.; the angle is 52° 20′, the apex is 9 ft. square, the casing from the top 130 ft. to 150 ft. It is placed in an excavation made in the solid rock. Belzoni, after great exertions, succeeded in opening this pyramid, which has two inclined entrances, one in the masonry of the pyramid itself 37 ft. 8 in. above the base, at an angle of 25° 55′, and 104 ft. 10 in. long; the lower one 96 ft. 4 in. long, at an angle of 21° 40′, placed before the base, both leading to a sepulchral chamber of 46 ft. 2 in. by 16 ft. 2 in., and 19 ft. 3 in. high, with a roof of the same shape as the pyramid, in which was found a granite sarcophagus 8 ft. 7 in. long, 3 ft. 6·5 in. wide, and 3 ft. high, close to the S. and W. sides of the chamber, on which was found a Cufic inscription, recording the visit of the Caliph Othman, and the opening of the pyramid by him in A.D. 1196-7. Some bones of a bull, but no human remains were found in this pyramid. The two lower tiers of the exterior and entrance have fresh coatings of granite, the casing is hard stone of Mokattam. The masonry is formed of blocks and rubble.

The third pyramid was built by Menkare, the Mycerinus of Herodotus, Mencheres of Manetho, and Moscheris of Eratosthenes, the third king of the 4th dynasty. A level for the site was obtained by a substruction more than 10 ft. deep, laid to the west, consisting of two tiers of immense blocks. The entrance of this pyramid was discovered by Colonel Howard Vyse, in July 1837, at a height of 13 feet above the base, and measuring 3 ft. 5½ in. by 3 ft 11½ in. The passage appears to have been forced by the Mamelukes. The base measured 354 ft. 6 in., the perpendicular height 218 ft., its angle was 51°. The passage entered at 26° 2′, ran for 104 feet, and led to an ante-room of 10 ft. 5 in. by 12 ft. and 7 ft. high, covered with white plaster worked in compartments, passing thence to three portcullises, a passage of 41 ft. 3 in. long, 3 ft. 5½ in. broad, and 5 ft. 10 in. high, led thence, at an angle of 4°, to the so-called large apartment, measuring 46 ft. 3 in. long by 12 ft. 7 in. broad, about 15 ft. high, in which was a place for a sarcophagus. A passage of 4 ft. 9 in. high thence descended for 30 ft. to a portcullis which closed the sepulchral chamber of 21 ft. 8 in. by 8 ft. 7 in., and 11 ft. 3 in. high, lined with granite, containing a sarcophagus of whinstone, of 8 ft. long by 3 ft. 1 in. broad, and 2 ft. 11 in. high, ornamented with plain architectural ornaments similar to those seen in tombs of the 4th dynasty. A room 17 ft. 6 in. long by 6 ft. 3 in. broad, and 6 ft. 7 in. high, containing niches, was reached by a series of 7 steps. The large apartment had an ascending passage similar to the first, of 80 ft. 4 in. in length by 3 ft. 5½ in. broad, and almost 4 ft. high.

The sarcophagus in the sepulchral chamber was subsequently removed by Colonel H. Vyse, and sent to the British Museum, but lost at sea off Carthagena; fragments of the lid were found in the entrance of the passage to the large apartment, and close to it portions of a mummy case of cedar, of the usual shape, inscribed with the name of the king Menkare, and a prayer to the goddess Nu, and part of a body with a woollen garment, supposed by some to be the body of the monarch, by others that of an Arab. The casing of this pyramid has been nearly all removed; according to Herodotus, it extended half way up of Ethiopian stone, but the greatest height of the black granite is now 36 ft. 9 in. on the west side; according to Diodorus there were only 15 layers of granite. The name of its builder, according to the same, was inscribed on its north side. According to Manetho, Mencheres reigned 63 years. It is evident that, on account of the increased length of reign, an important alteration took place in the construction of this pyramid, the increasing masonry having extended beyond the mouth of the first or upper passage, rendering necessary the construction of the second inclined passage and the present sepulchral chamber, in place of the large apartment originally destined for that purpose, the old red granite sarcophagus having been broken in pieces for the purpose of removal, and a new sarcophagus made for the lower chamber. The chiselling of the upper passage, which is from the outside, and that of the lower inclined passage, which is from the inside, show that this passage was worked after the completion of the masonry. The third pyramid is better constructed than the others.

The former height of the fourth pyramid of Gizeh, the central, south of the third, was 69 ft. 6 in., the length of the base on the rock, 102 ft. 6 in.; it had an inclined passage of 27 ft. leading to an ante-room, and another 11 ft. 8 in. long, leading at an angle of 27° to a small sepulchral chamber, in which was an empty granite sarcophagus 6 ft. 8 in. long; in it was found the cartouche of *Ramenka*, or Mycerinus, and it was supposed to have contained the wife or daughter of that monarch. The fifth, or eastern pyramid, south of the third, formerly had a square base, 145 ft. 9 in., a height of 83 ft. 4 in., an inclined passage of 27° 12′, of 86 ft. 9 in., and a horizontal one of 4 ft., leading to an apartment 25 ft. by 10 ft. 5 in., containing a sarcophagus of granite

above 8 ft. long; part of the 112th chapter of the Koran was found to have been formerly scrawled in it by some Arab visitant. The sixth, or western pyramid, south of the third, is 102 ft. 6 in. square at base, 69 ft. 6 in. high, with a passage of 30′ running 47 ft. 9 in., with an ante-room and sepulchral chamber. The seventh pyramid, north-east of the great pyramid, was formerly 111 ft. high, and 172 ft. 6 in. square, with an entrance passage of 55 ft. 3 in. long, inclined 33° 35′, leading to an ante-room and sepulchral chamber, without any sarcophagus. The eighth, central, east of great pyramid, of nearly the same dimensions, had had an entrance passage 37 ft. long, inclined 34° 5′, leading to an ante-room and sepulchral chamber. The ninth, south-east of the great pyramid, completing the Gizeh group, measures only 101 ft. 9 in. on a base 160 ft. square, with a passage of 53 ft., inclined 28°, to a sepulchral chamber. The entrances of all these pyramids were placed in front of the north face, generally at a little distance from the base.

The two largest pyramids were considered by the ancients one of the marvels of the world, and to be, as they actually are, sepulchres; but many absurd notions have been put forth by moderns as to their object, which has been supposed to have been to protect Memphis from the encroachments of sands, or imitation of Hindu edifices, or to square the circle, or vast reservoirs to purify the waters of the Nile, the burial place of Apis, or the granaries of Joseph. The best received hypothesis was, that the pyramids were for astronomical observation, and that the pole star was seen from the inclined passage, but it has been proved by Sir J. Herschel, that the pole star, *α* Draconis, of the age of Cheops, could never have been seen from the inclined passage. It is, however, generally agreed that the pyramids of this group are all of the age of the 4th dynasty, older than 2000 years B.C.

At Abou Roash, five miles N.W. of Gizeh, is a ruined pyramid of stone 320 ft. square at the base, without its casing, with a passage of 160 ft. at 22° 35′ inclination, leading to a sepulchral chamber 40 ft. by 15 ft., with chambers of construction; red illegible quarry marks were found in this pyramid. Another at Zowyet el Arrian, made of limestone from the neighbouring hills, is so rude in construction and destroyed as to have the appearance of a circular hill about 300 ft. broad, 61 ft. high above the rock. That of Reegah, situated near a deserted village of that name, about three-quarters of a mile N.W. of pyramid of Abooseer, composed of finer masonry cased with granite, rose at an angle of 75° 20′ with an upper part of Mokattam stone at 52°, and 123 ft. 4 in. square. Some sculptured stone, found N.E., had the names of Usren-Ra, king of the 3rd dynasty. At Abooseer are the remains of five pyramids—the Northern, cased with granite and Tourah limestone, had a base of 257 ft., reduced now to 216 ft., and rose 162 ft. 9 in., now reduced to 118 ft., at 51° 42′ 35″: it had a passage of 27° 5′ inclination, with an apartment in the centre with a destroyed sarcophagus of black basalt, and the name of Ra-sahu or Sahu-ra, king of the 3rd dynasty, was found in this pyramid. The middle pyramid, of rather larger dimensions, contained the name of the monarch Ra-Usr, of the 3rd dynasty. The great pyramid had been cased with granite. Its original base appears to have been 359 ft. 9 in.; now it is 325 ft., and it rose 237 ft. 10 in. high, now only 164 ft.; layers of split reeds painted red were found on the roof of the passage. The quarry marks contained the name and titles of a functionary. The small pyramid has only a base of 54 ft. 6 in., and was anciently only 78 ft. square. At Sakkara are eleven pyramids all built of stone, approached by inclined causeways from the plains below, and much decayed, except the large step-formed pyramid and that to the N.E. In the second pyramid remains of a plain basalt sarcophagus were found. The third step-shaped or great pyramid had an apartment covered with timbers, furnished with a hidden chamber. Its old base had been 351 ft. 2 in. by 393 ft. 11 in.; it is now 196 ft. 6 in. high. The doorway or entrance was encrusted with small coloured porcelain tiles worked into an inscription containing the name and title of the monarch Ra-nub-tam or probably the Chnonbos Gneuros of Eratosthenes. The fifth was entirely built of Tourah stone. The inscriptions in the third pyramid show that it was made for a high officer of state. At Dashour are five pyramids—three of stone and two of brick. The northern brick pyramid, supposed to be that of the Asychis of Herodotus, whose inscriptions boasted it was as superior to the stone pyramids as Jupiter to the other gods, formerly 218 ft. and now 90 ft. high, had a base of 350 ft. at an inclination of 51° 20′ 25″. This pyramid was anciently cased with stone, and had a portico of the same material, a portion of which was found, as also the end of a royal name resembling that of a king of the 12th dynasty. The south brick pyramid, much destroyed, is made of bricks mixed with straw and rubbish; it was cased with Mokattam stone, and the south stone one had an inscription with the name of a functionary. Two ruined stone pyramids are at Lisht; another, at Meydoum, called the false pyramid, which has not been opened, is supposed to belong to the 6th dynasty; that of Illahoun, also made of brick and stone walls; that of Howara, also of brick, has been cased with stone, has no inscription, but has been attributed to the 1st dynasty, whose 4th king Venephes or Venephres is said to have erected a pyramid at Kokome; those of Biahmoo, at Medinat El Fayoum, two in number, appear to have been the sepulchres of Amenemha IV., and Sebeknefru or Scemiophris, placed in the lake Mœris, near the Labyrinth, in the Arsinoite nome at Crocodilopolis. According to some these pyramids consist of the cores of the ancient monuments or pedestals of the statues of the kings. They are 23 ft. high, slope 64°, and stand on a layer of Nile mud. A ruined pyramid exists at El Kufa. At Thebes are some small pyramids of sun-dried bricks, the central chambers of which have vaulted roofs, supposed to be of the 16th century B.C. One of these at the Drah-Aboo-Negger, not facing the cardinal points, is entered by a passage leading to a chamber at the bottom of which is a tablet representing the king Enentef IV. of the 11th dynasty, followed by four dogs with their names. It is to this pyramid and the adjoining tombs that the Abbott papyrus refers. [PAPYRUS.]

The principal pyramids in Nubia are those of Beg e Rauie, about 17° N. lat., called by Cailliaud Assur, and Hoskins Begromi, which lie in three groups arranged in a crescent shape, and are the sepulchres of the monarchs of Meroe. They do not face the cardinal points, but the propylæa which are united to the pyramids all face the east, and the sepulchral chambers which are constructed in the masonry lie to the west. The inner walls of the sepulchral temples are ornamented with Osiris and other Egyptian deities, and the names and legends of the monarchs for whom they were made, one of whom had assumed the prænomen of Sesortesen I., but many of the names and inscriptions cannot be deciphered. The art is of a late period, but the number of kings show a long duration of empire. One of these pyramids had been encased and enlarged at a later period, and in another, Ferlini, in 1834, found a collection of solid gold rings, a bronze vase and other objects walled up. Another group of about one hundred and twenty lies at El Gues N. of Gebel Barkal, and at Nourri, 18° N. lat., another group of about twenty-five, the graves of the Æthiopian monarchs, whose capital was Mount Barkal, the ancient Napata, of which Tahraka was the most renowned monarch. The largest pyramid contains within it another of a different date, stone, and architecture. The base is about 155 ft., and the height about 104 ft. Other groups are at Tanqassi, Kurru, and Zuma.

Buildings of this shape are not confined to the valley of the Nile: the Birs Nimrud, of Belus, supposed to be the Tower of Babel, but now known to be a temple built by Nebuchadnezzar to the Seven Planets, in form of a step-shaped pyramid of different stages of appropriately coloured bricks 235 ft. high, with a perimeter of 2286 ft. The Mujellibe, also of pyramidal shape, is another edifice of brick-work erected by the same monarch; it is 140 ft. high, 600 ft. on the N., 657 on the S., 546 on the E., and 558 ft. on the W. side, and has a hollow shaft 60 ft. square. Xenophon, in his account of the retreat of the 10,000, also mentions a stone pyramid which he saw near the Tigris, about 45 miles S. of Mosul, about 200 ft. high. The tomb of Sardanapalus, at Tarsus, also appears to have been of pyramidal shape, and the mausoleum at Halicarnassus terminated in a step-shaped pyramid of 24 steps, rising 42 ft. 6 in., surmounted by a colossal quadriga. The idea seems borrowed from the Egyptians, with whom the Carians entertained at an early period political relations. Similar tombs, consisting of pyramids, supported on cellæ and columns or pilasters, have been found at Mylasa in Caria, at Oôrân near Ben Izli in Phrygia, at Celenderis in Cilicia, and elsewhere.

At Rome, within the walls of Aurelian, is a small pyramid 120 ft. high, and 95 ft. diameter, of marble face, formed of hewn stone upon a pavement of travertine, erected 20 or 30 years B.C. The door is on the N. side, and inside is a small sepulchral chamber with obliterated paintings on the walls and roof. It was erected in honour of C. Cestius, one of the seven marshals, *Epulones*, who furnished the banquets of the gods, according to the directions of his will by his executor M. Agrippa. There is an inscription on the front and back of the monument recording the name and title of the deceased, and that the work was begun and ended by Pontius and Pothas in 360 days—the Roman lunar year. It is generally known as the pyramid of Cestius, and was evidently imitated from the Egyptian.

There are some temples of pyramidal form at Benares, and other places in the East Indies, which are said to be copies of the sacred mount *Mene*, and are called *Meru Sringas*, or "Peaks of Meru." Pyramidal structures called *Leen tan*, representing the mountain of Yu, and used for sacrifice, exist at Pih-king, and have several stages ascended by flights of steps. Pyramidal temples have also been found at Suka in Java.

The Mexican pyramids called *Teocallis*, meaning "House of God," or "Temple," consist of pyramidal mounds of earth or stone, terraced, and mounted by steps, having on them the statues or altar of the god to whom they were dedicated, and where their bloody human sacrifices were performed. [MEXICAN ARCHITECTURE.]

Pyramidal structures called *morais*, of large size, are found in the Polynesian islands: a stone one at Atehuru, 270 ft. long, 94 ft. broad at base, and 50 ft. high, with a flat top reached by a flight of steps, the lowest 6 ft. high; the whole was cased with coral and basalt; another at Maeva was 120 ft. square. These structures were used as places of worship and burial. Easter Isle abounds in these *morais*. Colossal statues were often erected on the summits.

The pyramidal form in connection with sacred and sepulchral edifices appears to be distributed all over the world, and is nothing more than a geometrical mound; the facility of forming it, and the grand simplicity as well as the solidity and pleasing proportions of the figure, having caused it to be selected as best suited for primæval architecture.

(Long, *Egyptian Antiquities*, vol. ii. in the *Library of Entertaining Knowledge*; *Description de l'Égypte, Antiquités*, vol. v.; Sir G. Wilkinson, *Topography of Thebes*, 8vo, Lond., 1835; Col. Howard Vyse, *Operations carried on at Gizeh in* 1837, vols. i., ii., & iii., 8vo, 1840-1842; J. Gliddon, *Otia Ægyptiaca*, Lond., 1849, p. 20-51; R. Lepsius, *Ueber den Bau der Pyramiden*, in the *Monatsberichte der Akademie zu Berlin*, 1843, p. 177; K. J. Bunsen, *Egypt's Place*, 8vo, Lond., 1824; R. Lepsius, *Briefe aus Ægypten*, 8vo, Berlin, 1852, p. 197-239; A. Mariette, *Rev. Arch.*, 1860, p. 161; E. G. Squier, *The Serpent Symbol*, 8vo, New York, 1851, p. 72-106; also Jolowicz, *Bibliotheca Ægyptiaca*, p. 204 & foll.)

PYREN ($C_{30}H_{12}$?). A crystalline substance procured from gas-tar. It is insoluble in water, but crystallises in small rhombic laminæ in alcohol. It is insipid and inodorous, slightly soluble in alcohol and in ether. It melts at about 350° Fahr., and concretes on cooling into a crystalline mass. A stronger heat volatilises it without alteration. Sulphuric acid carbonises it. It much resembles paranaphthalin.

PYRIDINE ($C_{10}H_5N$). A volatile organic base found in bone-oil. In its properties it greatly resembles picoline. It yields the following derivatives:—

Chloroplatinate of pyridine . .	$C_{10}H_5N, HCl+PtCl_2$
Platinopyridine	$C_{10}H_3Pt''N$
Platosopyridine	$C_{10}H_4PtN$
Iodide of ethyl-pyridine . . .	$C_{10}H_5(C_4H_5)NI$

PYRITES. [METALS; *Iron, Bisulphate of.*]

PYROBENZOLIN. Synonymous with LOPHINE.

PYROCATECHIN. [PHENYLIC GROUP.]

PYROCITRIC ACID. [CITRIC ACID.]

PYROGALLIC ACID. ($C_{12}H_6O_6$). If the dry extract of nut-galls be heated to 356° Fahr. for 10 or 12 hours, a beautiful white crystalline substance sublimes, which is pyrogallic acid: 100 parts of the dry extract yield about 5 parts of the sublimed acid. Pyrogallic acid is soluble in 2¼ times its weight of cold water, and much less soluble in alcohol and ether. It does not redden litmus paper. Rendered alkaline with potash or soda, it rapidly absorbs oxygen, and assumes a blood-red colour. It is employed in eudiometry for the estimation of oxygen, and in photography for the development of collodion pictures.

PYROGUAIACIC ACID. [GUAIACYL.]

PYROINULIN. [INULIN.]

PYROLEIC ACID. [SEBACIC ACID.]

PYROLICHENIN. A substance obtained from the *Variolaria amara*. In order to procure it the powder of the lichen is to be treated with alcohol, and the solution evaporated to the consistence of a syrup. The pyrolichenin then crystallises, and after being washed with a solution of carbonate of potash it is to be dissolved in and crystallised from alcohol.

Its properties are:—It forms colourless inodorous crystals unalterable in the air, inodorous, and of a bitter taste. It fuses below 212° and concretes on cooling. It is insoluble in cold water, and slightly soluble in boiling water, and nothing is deposited from it on cooling. It is very soluble in alcohol, ether, bisulphide of carbon, and oils, both volatile and fixed. The alcoholic solution has an acid reaction, and, like the solution in acetic acid, and also in concentrated sulphuric acid, it is precipitated by water. It is not decomposed by the nitric, hydrochloric, or phosphoric acids.

It combines with ammonia, and forms yellow brilliant crystals, which effloresce in dry air. They are insipid, and dissolve readily in alcohol and the caustic alkalies. Solution of potash dissolves pyrolichenin with a wine-red colour, which gradually becomes brown. Acids precipitate from it a bitter reddish-brown substance. When decomposed by heat it yields no ammonia; and when heated in the air it burns with a bright sooty flame, which is violet-coloured on the edges. Its composition is not known: it is stated to possess antifebrile properties.

PYROLIGNEOUS ACID. [ACETIC ACID.]

PYROLITHOFELLIC ACID. [LITHOFELLIC ACID.]

PYROLIVILIC ACID. [OLIVILE.]

PYROLIZARIC ACID. [NAPHTHALIC GROUP.]

PYROMARIC ACID. [TURPENTINE.]

PYROMECONIC ACID. [MECONIC ACID.]

PYROMELLIC ACID ($C_{20}H_6O_{16}$). A crystalline organic acid, obtained by distilling mellic acid:—

$$\underbrace{3C_8H_2O_8}_{\text{Mellic acid.}} = \underbrace{4CO_2}_{\text{Carbonic acid.}} + \underbrace{C_{20}H_6O_{16}}_{\text{Pyromellic acid.}}$$

PYROMETER (literally "fire-measurer," from πῦρ, "fire," and μέτρον, "a measure"). No fluid has hitherto been found applicable to the construction of thermometers capable of indicating higher temperatures than that of boiling mercury (about 660° Fahr.). The term pyrometer was first employed by Muschenbroek to designate an instrument invented by him for measuring the effects produced in the dimensions of solid bodies by the application of heat; but the signification of the term has since been extended so as to include those instruments the object of which is to measure all gradations of temperature above those which can be indicated by the mercurial thermometer.

Muschenbroek's pyrometer consisted of a metallic bar, about six inches in length, one extremity of which was fixed, while the other was left free to advance as the metal elongated from the effect of the flames of several spirit-lamps placed beneath, which at each experiment were charged with the same quantity of highly rectified spirit of wine. The advance of the moveable extremity gave motion to a pinion and wheel, the latter of which drove an index over a graduated circle, each degree of which corresponded to a linear expansion of 12,500th of an inch. The instrument, as it was originally constructed, is described in the second part of Muschenbroek's translation of the 'Saggi di Naturali Esperienze fatte nell' Academia del Cimento,' Leyden, 1731; and as improved by Desaguliers (who substituted fine cords and friction-rollers for the wheel and pinion), in his 'Experimental Philosophy,' vol. i.

To Muschenbroek's pyrometer succeeded those of Ellicott (described in the 'Phil. Trans.' for 1736 and 1751), Graham ('Phil. Trans.,' 1754), Smeaton, Ferguson ('Lectures'), &c., which, like those that have since been constructed, with few exceptions, down to the present time, evince but little originality in the principle upon which they rest. A bar of metal is in most cases subjected to the direct action of flame, or immersed in a fluid of convenient temperature. The minute resulting expansion is multiplied, and thereby rendered appreciable by the intervention of a succession of levers or a system of wheels and pulleys. Supposing this intervening machinery to perform with theoretical accuracy, and that the same quantity of heat is successively communicated to different substances, the indications of such an instrument would give the relative expansions of those substances under the same circumstances. But where wheels, pinions, levers, &c., are employed, there must be considerable liability to error, arising from flexure, obliquity of action, and other causes, the magnitude of which it would be difficult to estimate, and which, even if it be supposed small in the first instance, will be magnified almost in the same proportion as the delicacy of the instrument is increased. Moreover the substance itself, if its nature be such as to be softened by heat, is very liable at high temperatures to undergo compression in giving motion to the machinery. Even, therefore, as measures of expansion they cannot be considered as deserving of much confidence. A similar remark is applicable, though in a less degree, to the contrivance employed by Lavoisier and Laplace, in which the expansion of the metal deflected a telescope from the position that it had at the commencement of the experiment, and the absolute expansion was deduced from the extent of this deflexion, which was read off upon a graduated scale placed at a considerable distance in front of the telescope. A description of the apparatus employed is given in Biot's 'Physique Expérimentale,' tome i., and a table of the expansions of the several substances experimented on between the temperatures of 32° and 212° Fahr. Troughton, in 1794, constructed an instrument which bore some resemblance to the preceding, the principal difference consisting in the employment of a spirit-level, the deviations of which from the horizontal determined the expansion of the metal.

The 'Phil. Trans.' for 1777 contain a description of the method employed by De Luc in the construction of his compensating pendulums, in order to determine the length of one metal whose expansion is equal to a given length of another metal. For this purpose he suspended the bar of known length from an arm projecting horizontally from an upright deal plank. To the lower extremity of this bar was adjusted a small horizontal platform, upon which a bar of the other metal rested in a vertical position. Upon raising the temperatures of both bars, every point on the surface of the second bar would obviously become subjected to two motions tending to move it in opposite directions: it would be depressed by the expansion of the first bar, and elevated by the expansion of the second. One point would therefore remain stationary, and this point, being ascertained by raising or lowering a microscope adjusted to the edge of the plank, determined the portion of the second bar, measured from its lower extremity, whose expansion was equal to the whole of the first bar.

The rods employed by Borda in measuring the base-line of the great French Survey consisted of a rule of brass laid upon a somewhat longer rule of platinum and attached at one extremity. The portion of the platinum rule not covered by the one of brass was divided into millionths of the entire length of the rule, and further subdivided by means of a vernier and microscope adjusted to the extremity of the brass rule. The value of each of these divisions having been previously ascertained by first surrounding the compound rule with melting ice, and then immersing it in boiling water, it was only necessary to observe the indications of the vernier in order to apply the requisite correction for reducing the length of the rod to the standard temperature.

For low temperatures, the contrivance of Ramsden, described in the 'Phil. Trans.' for 1785, and employed by General Roy in determining the expansion of the rods used in measuring the base on Hounslow Heath for the Trigonometrical Survey, was perhaps unexceptionable. The rod was immersed in a trough of water, and over each extremity was placed a microscope, to which a slow motion could be given in the direction of the length of the rod by means of a fine micrometer screw. The lines of collimation of the microscopes being thereby adjusted at the commencement of the experiment so as to coincide accurately with two points near the extremities of the rod, the temperature of the water was gradually raised till a thermometer placed in the trough indicated an advance of 10°, 20°, 30°, or any required number of degrees. The consequent elongation of the rod destroyed the coincidence of its extremities with the lines of collimation of the microscopes, which was re-established by turning the micrometer screws, and carefully noting the number of turns and fraction of a turn necessary for that purpose; when, the value in parts of an inch of each turn being previously known, a direct measure of the expansion was obtained, free from the errors of a system of levers or of a train of wheels and pinions.

The property of alumina whereby it undergoes a diminution of bulk when heated, was employed by Wedgwood as a measure of high temperatures. His pyrometer consisted of cylinders of fine white clay, and an apparatus for accurately measuring their length. This apparatus consisted of a metallic plate, upon which were fixed two brass rules slightly inclined to each other. The rules used by Wedgwood were 24 inches long, and divided into 240 equal parts. The distance between the rules at one extremity was 3-10ths and at the other 5-10ths of an inch; consequently the difference between their distances at any two consecutive divisions was the 1200th part of an inch. But it is obvious that these numbers are quite arbitrary, and that by increasing the length of the rules and diminishing their inclination, the difference between their distances at any two consecutive divisions may be made as small as we please. The clay cylinders were first baked at a red heat, estimated at 947° Fahr., and then reduced to exactly 5-10ths of an inch in length, so as to fit the first division of the scale. When afterwards exposed to a greater heat, they underwent contraction, and the amount of this contraction was determined by observing the division of the scale corresponding to their diminished length. If we then assume, with Wedgwood, that the contraction is proportional to the temperature at which it took place, the latter will likewise be determined; but independently of the difficulty of procuring pieces of clay of uniform composition, from which it resulted that two cylinders of equal length when exposed to the same heat seldom underwent the same degree of contraction, it has been found that the duration of the experiment has considerable influence upon the contraction, the longer continuance of a low temperature producing the same contraction as a higher degree of heat continued for a shorter time. As a measure of temperature, therefore, this method cannot be relied on, though as a direct measure of expansion we doubt if it has been surpassed either in the simplicity of its principle or in the minuteness of the indications of which it is susceptible. A description of the instrument, and of the experiments made with it, will be found in the 'Phil. Trans.' of 1782, 1784, and 1786.

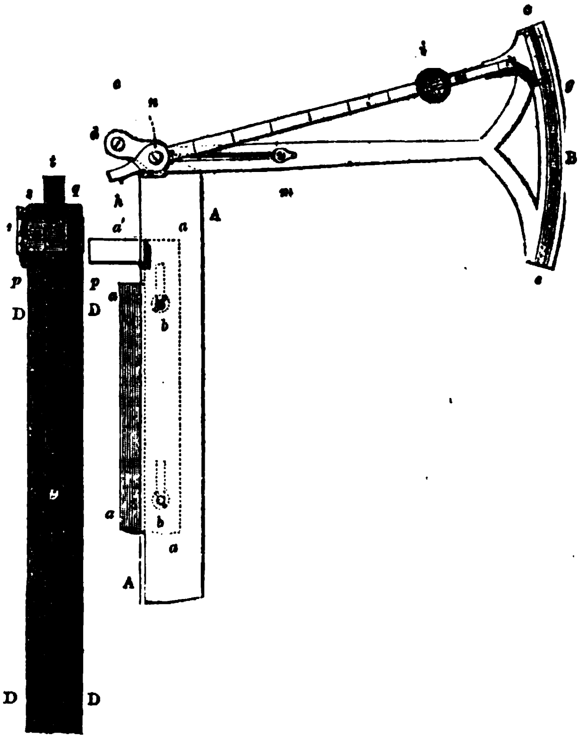
A pyrometer was constructed by Achard similar in form and principle to the common thermometer, but intended to indicate much higher degrees of heat. It consisted of a bulb and graduated tube of semi-transparent porcelain highly baked, and containing a very fusible alloy, composed of bismuth, lead, and tin, which became liquid at about 212°, and indicated higher temperatures by its expansion, which was visible through the semi-transparent tube.

Dulong and Petit employed a very direct mode of measuring the absolute, not linear, expansions of various substances. By observing the difference of altitude at which mercury of different temperatures stood in the two arms of an inverted glass siphon, they determined the absolute expansion of the mercury, and by comparing this with the apparent expansion of mercury in a glass tube, they deduced the absolute expansion of the glass. A cylinder of the metal whose expansion was sought was then placed within a glass tube, closed at one extremity and terminating at the other in a capillary opening, and the rest of the tube occupied with mercury. Upon the whole being heated, a portion of the mercury was expelled equal to the excess of the absolute expansions of the mercury and metal above that of the glass; and as the expansions of the mercury and glass were previously known, the weight of the expelled mercury determined the expansion of the metal.

Sir David Brewster has proposed to measure expansions by the number and intensity of the polarized tints produced by the inflexion of a plate of glass against which the expanding substance is made to press. (Brewster's 'Cyclopædia,' articles 'Pyrometer' and 'Optics.')

Guyton's pyrometer, which was exhibited before the National Institute in 1803, and described in the 'Annales de Chimie,' xlvi., p. 276, and in Nicholson's 'Philosophical Journal,' vi., p. 89, consisted of a bar of platinum nearly 2 inches in length, placed in a groove of porcelain. One extremity of the bar rested against the solid end of the groove, while the other pressed upon the short arm of a lever, the longer arm of which carried a vernier over a graduated circular arc. The whole was constructed of platinum, and a spring was made to press upon the vernier to prevent its displacement while in the act of withdrawing the instrument from the furnace. The indications of the vernier at the commencement and termination of the experiment were the data from which the expansion was subsequently puted. "The defect of this instrument," observes Mr. Daniell, "arose from the nature of platinum, which at a red heat becomes soft and ductile, so that the lever would be liable to bend, and thereby frustrate the experiment; and this is supposed to have been the reason why the inventor never extended his experiments to temperatures higher than that of the melting point of antimony."

As early as 1821, Professor Daniell had invented an instrument which, he states, "afforded correct determinations connected in an unexceptionable manner with the scale of the mercurial thermometer;" but it was only suited to the experimental furnace of the chemist, so that, he continues, "the great desideratum still remained of a pyrometer which might be universally applied to the higher degrees of heat, as the thermometer had long been to the lower, and which, in addition to its use in delicate researches, might effect for the potter, the smelter, the enameller, and others, in the routine of their business, what the latter daily performs for the brewer, the distiller, the sugar-refiner, and the chemist." The annexed diagram represents the second pyrometer invented by Mr. Daniell, for which the Rumford medal was awarded to him by the Royal Society. An account of it is given in the 'Phil. Trans.' for 1830-31.



It consists of two distinct parts, the register and the scale. The register is a solid bar of black-lead earthenware, D D D D, eight inches long and seven-tenths of an inch wide and thick, cut out of a common black-lead crucible. In this a hole is drilled three-tenths of an inch in diameter, and seven inches and a half in depth. At *p p* the upper end of this bar, and on one of its sides about six-tenths of an inch in length of its substance, are cut away to the depth of half the diameter of the bore. When a bar of any metal six inches and a half long is dropped into this cavity, it rests against its solid end; and a cylindrical piece of porcelain, *q*, about one inch and a half long, called the index, is placed on the top of it, which, projecting into and beyond the open part, is firmly confined to its place by a strap of platinum, *r*, which passing round the black-lead bar and over the piece of porcelain, is made to press upon the latter with any required degree of tension by means of a small wedge *s* of porcelain inserted between the bar and the strap. When the register is exposed to the heat of a furnace, it is evident that, the expansion of the metallic bar exceeding that of the black-lead, the porcelain index will be forced forward; and when the register is afterwards cooled, the tension of the strap will retain the index at the point of greatest elongation.

The object of the scale is the accurate measurement of the distance through which the index has advanced. It consists of a frame, *a a a a*, composed of two rectangular plates of brass joined at right angles by their edges, and fitting square upon two sides of the register. At one extremity of this frame is a small plate of brass, *a'*, which, when the two former plates are applied to the register, is brought down upon the shoulder formed by cutting away the black-lead at *p*, and the whole may be thus firmly adjusted, when required, to the black-lead bar by three planes of contact. To the outside of this frame is firmly attached, by means of the screws *b b*, a brass plate A A, the extremity of which, *d*, projects so that a point, *c*, near to it may be immediately opposite to the cavity in the black-lead bar when the latter is adjusted to the frame. About *c* as a centre, turns an arm *d n* B slightly bent at *n*, carrying at its extremity a graduated circular arc *e e*. The radius of this arc is five inches, and its moveable centre *n* is distant from the fixed centre *c* exactly half an inch. About *n* turns a straight and lighter arm, *h g*, five inches and a half in length, the distance from *h* to *n* being half an inch. The extremity, *g*, of this arm carries a vernier, by which the divisions of the graduated arc are subdivided into minutes, and also an eye-glass, *i*, to assist the reading. The other extremity terminates in a steel point, *h*, or, as the instrument is now constructed, a knife-edge, which, when the register is adjusted to the frame, is inserted in a small cavity, *t*, formed for its reception at the extremity of the porcelain index. A small steel spring let into the larger arm at *m* is made to press upon the lighter arm, whereby the latter has a constant tendency to move towards the commencement of the graduation.

When the instrument is used, the metallic bar to be experimented on is placed in the cavity of the register, and the index pressed down upon it and firmly fixed in its place by the platinum strap and porcelain wedge. The scale is then applied by carefully adjusting the frame to the register and fixing it by pressing *a'* upon the shoulder. Holding the whole together steadily in the left hand, the lighter arm is so placed that the steel point *h* may rest upon the edge of the index, against which it will be pressed by the spring; then by slightly turning the larger arm, the point will move along the surface of the index till it drops into the cavity *t*. The indications of the vernier being then read off, the register is detached from the scale, placed in the furnace, and after it is removed and cooled, it is again applied to the scale in the same manner as before, and the second indication of the vernier noted. From the two readings of the vernier may be deduced the excess of the expansion of the metallic bar above that of the black-lead, though a correct formula for this purpose has not, to the writer's knowledge, been hitherto given.

The one employed by Mr. Daniell, though probably sufficiently correct for all practical purposes, gives the expansions one per cent., too great without exception, and in many cases much more, so that more than the first *significant* figure can seldom be depended upon in those published by him in the 'Phil. Trans.' of 1830-31. The error thus introduced is perhaps within the limits of the error to which the instrument itself is liable; but should this not be the case, it might be desirable to employ the correct formula, for which reason we subjoin its investigation.

Let $c n \mathrm{B}$, $h n g$, represent the positions of the two arms of the scale relative to the register, before the expansion has taken place, and $c n' \mathrm{B}'$, $h' n' g'$, their positions after the expansion; h and h' the two positions of the steel point, the line joining which passes through the fixed centre c; e and e' the two positions of the zero of the graduated arc. Put the angle $e n \mathrm{B} = c n' \mathrm{B}' = \alpha$; $e n \mathrm{B} = e' n' \mathrm{B}' = \beta$; $e n g$ (the first reading of the vernier) $= \phi$; $e' n' g'$ (the second reading) $= \phi'$; also $c n = c n' = n h = n' h' = r$; and $h h' = \epsilon$, the excess of the expansion of the metal above that of the black lead: then

$$\epsilon = \frac{\sin h n n' - \sin h' n' n}{\sin h' h n - \sin h h' n'} \times \text{chord } n n';$$

$$\begin{aligned} \text{But}\quad h n n' &= 270^\circ - \alpha + \beta - \tfrac{1}{4}(3\phi + \phi'); \\ h' n' n &= -90^\circ + \alpha - \beta + \tfrac{1}{4}(3\phi' + \phi); \\ h' h n &= \tfrac{1}{2}(\alpha - \beta + \phi); \\ h h' n' &= 180^\circ - \tfrac{1}{2}(\alpha - \beta + \phi'); \\ \text{chord } n n' &= 2 r \sin \tfrac{1}{2}(\phi' - \phi); \\ &= \sin \tfrac{1}{2}(\phi' - \phi), \text{ since } r = \tfrac{1}{2}. \end{aligned}$$

$\therefore$ substituting and reducing by means of the formula

$$\sin \mathrm{A} - \sin \mathrm{B} = 2 \cos \frac{\mathrm{A} + \mathrm{B}}{2} \sin \frac{\mathrm{A} - \mathrm{B}}{2}, \text{ there results}$$

$$\epsilon = 2 \sin \tfrac{1}{4}(\phi' - \phi) \sin \left\{ \tfrac{1}{2}(\alpha - \beta) - \tfrac{1}{4}(\phi' + \phi) \right\}$$

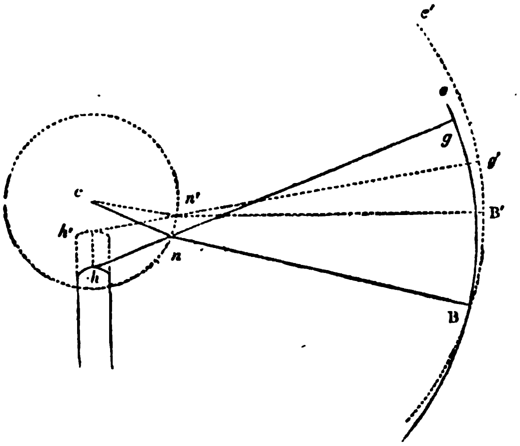
If $\alpha = 180^\circ$ and $\beta = 15^\circ$, as is nearly the case, this reduces to

$$\epsilon = 2 \sin \tfrac{1}{4}(\phi' - \phi) \cos \left\{ 7^\circ\, 30' + \tfrac{1}{4}(\phi' + \phi) \right\},$$

where the unit of measurement is one inch.

The formula used by Mr. Daniell is $\epsilon = \sin \tfrac{1}{2}(\phi' - \phi)$, or its equivalent, since $\phi' - \phi$ is generally a small angle, $\epsilon = 2 \sin \tfrac{1}{4}(\phi' - \phi)$; from which it appears that all the expansions given by him should be diminished in the ratio of $1 : \cos \left\{ 7^\circ\, 30' + \tfrac{1}{4}(\phi' + \phi) \right\}$; but as he has recorded only the difference $\phi' - \phi$ of the readings of the vernier, and not the readings themselves, this correction can only be made by a repetition of the whole of the experiments. The error is inconsiderable so long as ϕ and ϕ' are both small, but it increases with the increase of either of those angles.

The excess of the expansion of the metal above that of the black-lead being thus obtained, and increased by the expansion of the latter (the determination of which is less direct and conclusive), the expansion of the metal becomes known. In order that the instrument may then be employed as a measure of temperature as well as of expansion, the doubtful assumption is introduced that equal increments of length are the effects of equal increments of temperature, and thence, having determined the expansion between any two known points on the thermometric scale, say the temperatures of melting ice and boiling mercury, a mere proportion will of course give the temperature at which any other observed expansion took place.



A paper was communicated to the Royal Society by the late Mr. Prinsep, the assay-master of the Mint at Benares, "On the Measurement of High Temperatures,' and published in their 'Transactions' for 1828. "The fusing-points of pure metals," observes that gentleman, "are determinate and unchangeable; they also comprehend nearly the whole range of temperature; the unoxidable or noble metals alone embrace a range from the low melting-point of silver to the high ignition of platina. There are, it is true, only three fixed points in this scale, but as many intermediate links may be made as are required, by alloying the three metals together in different proportions. When such a series has been once prepared, the heat of any furnace may be expressed by the alloy of least fusibility which it is capable of melting." As the melting-points of silver and gold are comparatively near to each other, Mr. Prinsep assumed only ten intermediate gradations of heat, the lowest of which corresponded to the fusing-point of pure silver, and the others to the fusing-points of silver alloyed with 10, 20, 30, &c. per cent. of gold. From the melting-point of gold to that of platina, he assumed one hundred gradations of heat, which were the melting-points of pure gold and of gold alloyed with 1, 2, 3, &c., per cent. of platina. Among the advantages of this mode of identifying temperatures are; — the smallness of the requisite apparatus, nothing more being needed than a small cupel, containing in separate cells eight or ten pyrometic alloys, each of the size of a pin's head; the indestructibility of the specimens, since those melted in one experiment need only to be flattened under a hammer, when they will be again ready for use; and the facility of notation, since two letters and the decimal of alloy will express the maximum heat: thus s ·3 g expresses the temperature of the fusing-point of silver when alloyed with gold in the proportion of 7 to 3; and g ·23 p expresses the fusing-point of gold when alloyed with platina in the proportion of 77 to 23.

Several suggestions have been made for employing the expansion of air, on the principle of the differential thermometer, as a measure of high temperatures. It is proposed that one-half of the instrument be composed of platinum, so as to fit it for exposure to a great heat, and the other part of glass. The suggestion, we believe, is originally due to Mr. Schmidt (Nicholson's 'Journal,' xi.); but was brought forward under another form by Mr. Nicholas Mill, in the 'Monthly Medico-Chirurgical Review and Chemico-Philosophical Magazine,' vol. i., Lond., 1824; again by Dr. Ure, in his 'Dictionary of Chemistry;' and lastly by Mr. Prinsep. The instrument, we believe, has been constructed upon each of the plans proposed. That of Mr. Prinsep appears the most complete (see a drawing of the apparatus in full operation at page 87 of his Memoir above referred to), and was employed by him to connect the fusing-points of his alloys with the thermometric scale; but the principle upon which they all rest involves the assumption that the increase of temperature is proportional to the expansion of the air.

A valuable table of the expansions of different substances collected from various sources by Mr. Francis Baily, is given in the first volume of the 'Transactions of the Astronomical Society,' p. 416.

The above admirable article well nigh exhausts the subject of the pyrometer. Since the date of its publication in the 'Penny Cyclopædia,' very little has been done towards perfecting this instrument. We may, however, briefly notice a few points of interest in connection therewith.

Mr. Prinsep's method of alloys was tested some years ago in the laboratory of the Sèvres porcelain manufactory, with a view to determine the temperatures of the kilns used in baking porcelain. It was found necessary to expel silver from the brief list, on account of its absorbing oxygen when in a state of fusion and spitting it out again when cooling. Alloys of platinum and gold in various proportions were tried, but it was found that similar alloys did not always melt at the same moment, although apparently placed under precisely the same circumstances. It was also found that the same bead of alloy could not be used more than once, on account of some molecular change produced by the heat which led to an alteration in the fusing point. It was however determined that the highest temperature attained in the kiln at Sèvres was represented by the alloy $\left.\begin{matrix}\text{P. } 53\\ \text{G. } 47\end{matrix}\right\}100$, when a well fused button was formed; whereas when 54 parts of platinum were used, only a softening of the alloy was perceived. M. Brongniart, 'Traité des Arts Céramiques,' remarks that if it be possible to determine exactly and promptly the moment when complete fusion takes place in these alloys, they will afford comparable measures of high temperatures; but not a method fit to be employed habitually in industrial operations.

So long since as the year 1805, M. Brongniart constructed a pyrometer for measuring the comparatively moderate heat of the glass oven, or muffle furnace at Sèvres, by means of the dilatation of a bar of silver. The readiness with which this metal can be obtained pure renders the results of two instruments comparable, although it is not adapted to measure very high temperatures. The bar of silver is two decimetres in length, and it is placed among the articles which are being fired, resting in a groove of hard porcelain, one end of which is turned up to serve as a fixed point to the further end of the bar, while the near end presses against a porcelain rod, which gives motion to a needle over a graduated arc. For further particulars we must refer to M. Brongniart's work, above cited.

In the Great Exhibition of 1851, Mr. Ericsson exhibited in the United States department an instrument intended to supply what we think is still a desideratum, namely, a good pyrometer for the useful arts. In this instrument temperatures were indicated by the tension of a permanent volume of air, or of nitrogen gas, which was measured by the reading of a column of mercury under a vacuum. For the particulars of this instrument we must refer to the Jury Report.

In the 'Transactions of the Royal Society of Edinburgh,' vol. xiii. will be found an account of an ingenious pyrometer by Mr. Adie, for measuring the expansion of different kinds of stone. We have not space to describe the instrument, but we may mention one curious effect, namely, that there was an increase in length in white Sicilian marble, every time its temperature was raised.

We may also refer to M. Pouillet's method of measuring directly the linear expansion of solids applicable to very high temperatures. It consists of a solid plate of metal on which is placed a radius turning on a centre, and traversing a graduated arc, the divisions of which are read off by a microscope. The radius carries a telescope of short focus, fixed at right angles to its direction, while a similar telescope is fixed to the plate itself, allowing the radius to traverse under it. The bar which is the subject of experiment is placed in a copper trough, furnished with parallel plates of glass, through which its ends can be seen. Now if one extremity of the bar be kept opposite the fixed telescope, while the moveable telescope is directed to the other extremity at the commencement of the observation, any expansion of the bar caused by raising its temperature may be estimated by the arc through which the radius must be turned in order to bring the moveable telescope to bear on the other extremity in its new position, the distance of the radius from the bar being accurately known. For very high temperatures the bar may be placed in a furnace, and when raised to the required temperature, apertures may be opened in the furnace walls, so as to give a view of the ends of the bar, and allow its expansion to be measured as before. By means of this apparatus an expansion in the bar of $\frac{1}{1000}$th millimetres or about $\frac{1}{25000}$th inch can be appreciated.

We may also refer to an ingenious contrivance adopted by General Colby in measuring the base line of Loch Foyle, for the Ordnance Survey of Ireland. It consisted of a compound bar of iron and brass so arranged that their different powers of expansion and contraction should preserve exactly the same distance between two points at the extremities of the bars, instead of allowing for the change in length according to the observed temperature. The two bars, one of iron the other of brass, each 10 feet long, were placed parallel to each other and riveted together in the centre. It was ascertained by experiment that the iron and brass bars expanded and contracted by varying temperatures in the proportion of three to five. Across each extremity therefore of these combined bars was fixed a tongue of iron, with a minute dot of platinum so placed, that under every degree of expansion and contraction of the rods the dots at each end always remain at the constant distance of 10 feet.

PYROMORINTANNIC ACID. [Oxyphenic Acid.]

PYROMUCIC ACID. [Mucic Acid.]

PYROPECTIC ACID. [Pectic Acid.]

PYROPHORUS. [Lead: *Tartrate of.*]

PYROPHOSPHORIC ACID. [Phosphorus.]

PYROPIN. A red albuminous substance found in elephants' teeth.

PYROSIS, or WATER BRASH, is a disorder of the stomach, attended with the vomiting or eructation of a thin watery liquid.

This liquid is usually insipid and tasteless, but sometimes it has an acid taste. Cullen speaks of this disease as a common complaint in Scotland, and it has been attributed to the employment of farinaceous food, especially oatmeal, as an article of diet. It usually comes on in the early part of the day when the stomach is empty. The first symptom of it is a pain at the pit of the stomach, with a sense of constriction as if the stomach were drawn towards the back. The pain is increased by raising the body into an erect posture, and therefore the body is bent forward. The pain is often very severe, and after continuing for some time it brings on an eructation of a thin watery fluid in considerable quantity. These symptoms often occur without any other indications of dyspepsia, although they are not unfrequently accompanied with other indications of derangement of the digestive organs. It sometimes occurs with violent neuralgic pains of the stomach, constituting gastrodynia. Pyrosis also accompanies organic disease of the stomach.

In the treatment of this disease, the preparations of opium with bismuth and astringents, as kino and catechu, are found to be of most service; at the same time the bowels require to be kept open, which should be done by means of castor oil, confection of senna, or other mild purgative.

PYROXAM. [XYLOIDIN.]

PYROXANTHIN ($C_{20}H_{8}O_{4}$?). A beautiful yellow crystalline product of the action of alkalies upon wood-tar. Concentrated sulphuric and hydrochloric acids dissolve it with the production of a dark red colour.

PYROXYLIC SPIRIT. [METHYL, *hydrated oxide of.*]

PYROXYLIN. [GUN COTTON.]

PYRROL. A volatile oily alkaloid, discovered by Runge in coal-tar. Its composition is not known. Anderson regards it as a mixture of several substances.

PYTHIAN GAMES (*Pythia*, or *Pythici Ludi*), one of the four great national festivals of the Greeks, were celebrated near Delphi, in honour of Apollo, originally every ninth year, and afterwards every fifth year, in the autumn of the third year of each Olympiad, in the second or third month of the year, according to Clinton. Corsini and others, followed by Boeckh, place them in the spring, in the month Munychion, the tenth of the year. Their origin is assigned by some to Amphictyon, the son of Deucalion, or to the Amphictyonic council; by others to Agamemnon; by Pausanias to Diomed; by Strabo to the Delphians, after the Crissæan war; but most commonly to Apollo, after he had vanquished the serpent Python. (Ovid, 'Met.', i. 445.) There is an account that the gods and heroes contended in the first celebration of these games, when Castor conquered in the horse-race, Pollux in boxing, Calais in the foot-race, Zetes in fighting in armour, Peleus in throwing the quoit, Telamon in wrestling, and Heracles in the Pancratium. But the fact seems to be, as stated by Pausanias (x. 7, 2) and Strabo (ix., p. 421), that the contest was originally in music: the songs (πυθικοὶ νόμοι) were in honour of Apollo, celebrating his victory over the Python; and the instrument used was the lyre. In the third year of the 48th Olympiad (B.C. 586), at the close of the Cirrhæan war, the Amphictyons added a contest on the flute, which was afterwards discontinued, as the music of the flute was considered too mournful for a joyous festival. In the same year the Amphictyons also introduced athletic contests and races (but not with four-horsed chariots), the foot-race being confined to boys; and the games, according to Strabo, were then for the first time called *Pythia*; at all events the subsequent Pythia are computed from this year by Pausanias and the Parian marble, though the scholiast on Pindar, and Eusebius, date them from the second celebration, in Ol. 49, 3: Boeckh and Clinton prefer the former date. Chariot-races were added in the time of Cleisthenes, the tyrant of Sicyon. Statues, pictures, and other works of art, were also exhibited at the Pythia, and prizes adjudged to the most successful artists. The prize in the Pythian games was originally of silver or gold, or something else of intrinsic value; but afterwards a crown of laurel, or (according to Ovid, 'Met.', i. 449-50) at first, of the bay-oak or beech-tree (*æsculus*), for which the laurel was afterwards substituted. The ceremonies observed at these games in common with the three other great festivals, are described under OLYMPIAN GAMES. The attendance at the games was very great, as all Greeks were permitted to be present at them. The Pythia are believed not to have been entirely discontinued till about the same time as the Olympian games, 394 A.D.

(Pausanias, x. 7; Strabo, ix.; Potter's *Archæologia Græca*, vol. i.; Wachsmuth, *Hellenische Alterthumsk.*; Clinton, *Fasti Hellen.*; Krause, *Die Pythien.*)

PYX, or **PIX**, the box or casket in which is kept the consecrated host reserved for the sick in the Romish church. Among the ancients the pyxis (πύξις) was the casket in which ladies kept their jewels and other ornaments. It was itself often made of the most costly materials, and enriched with sculpture or with gems. There can be little doubt that it was from the ancient jewel-box that the mediæval ecclesiastics derived the name of their pyx, and perhaps also the idea of its enrichment. At any rate the pyxes of mediæval date which still remain are among the costliest examples of the art-workmanship of the middle ages. Some good ones are in the South Kensington Museum; others are preserved among the plate of some of the colleges of Oxford and Cambridge, but the finest are in the treasuries of continental churches. The pyx was placed upon the altar under a covering or canopy, and at its elevation the sacring bell was rung. Among the French especially the pyx seems to have been not unfrequently in the form of a dove, enamelled and enriched with gems. The term pyx was sometimes applied to the casket in which relics were kept. [RELIQUARY.]

PYXIS NAUTICA (the mariner's compass), a southern constellation of Lacaille, placed in Argo. It contains no stars of conspicuous magnitude.

POLARIZATION OF LIGHT is a peculiar affection of that agent to which the term has been applied because a ray of polarized light possesses properties which have relation to two opposite directions in a plane perpendicular to the ray. We shall first describe some of the circumstances under which polarized light is formed, and the characters by which it is recognised as polarized, and afterwards explain the view which is taken of its nature in the theory of undulations, the only theory which has given a simple and intelligible account of its complicated phenomena.

The affection of light now known as polarization was discovered by Huygens in the course of his researches on the laws of double refraction in Iceland spar. A rhomb of this crystal has the property of dividing a ray of light incident upon it into two rays, which are propagated in different directions within the crystal, and produce each an emergent ray parallel to the incident, so that the two emergent rays are separated laterally by a space proportional, *cæteris paribus*, to the thickness of the rhomb, the direction of separation (supposing for simplicity the ray to be incident perpendicularly) being that of a line bisecting an obtuse angle of the rhombic face, and the intensity of the two emergent rays being under ordinary circumstances the same. Such a rhomb gives two images, of equal intensity, of an object on which it is placed. Now Huygens found that either of the pencils separated by a first rhomb is affected by a second rhomb quite differently from a pencil of common light. When the second rhomb is placed with its faces parallel to the corresponding faces of the first rhomb, so that the two are in the same relative position as if they formed parts of a larger block of the crystal, each pencil separated by the first rhomb furnishes only a single pencil in the second rhomb, the ordinary only an ordinary, and the extraordinary only an extraordinary, the two being separated on emergence as much as if they had been transmitted through a single block having a thickness equal to the sum of the thicknesses of the two rhombs. If now the second rhomb be turned round the common normal to the adjacent faces of the two rhombs, each pencil transmitted by the first rhomb is immediately divided into two by the second rhomb, the pencil (O) which suffered ordinary refraction in the first rhomb furnishing besides the ordinary pencil (O O) in the second a faint extraordinary pencil (O E), and the pencil (E) which suffered extraordinary refraction in the first rhomb furnishing besides an extraordinary pencil (E E) in the second a faint ordinary (E O); the direction and amount of separation of the pencils O O and O E, and likewise of E O and E E, being those due to the azimuth and thickness of the second rhomb, while the direction and amount of separation of O O and E O, and likewise of O E and E E, are those due to the first rhomb. On continuing to turn, the faint pencils O E and E O become brighter and brighter, and the bright pencils O O and E E fainter and fainter, until the rotation amounts to 90°, when the original pencils O O and E E disappear altogether, the whole of the light of O (not counting the small portion lost by reflection) now passing into O E, and the whole of the light of E into E O. On further turning, the pencils O O, E E which vanished reappear, and appropriate to themselves more and more of the light of O, E, respectively, until the rotation amounts to 180°, when the pencils O E, E O vanish, while O O, E E become as bright as at first, their lateral separation being now, however, that due to the *difference* instead of the *sum* of the thicknesses of the rhombs. On continuing to turn, the same changes recur periodically, each pair of images vanishing alternately at every quarter of a revolution.

Now imagine the ordinary pencil O to be isolated by means of a screen, and presented for observation, the apparatus by which it was produced being hidden from the observer. By examining it with a rhomb of Iceland spar he could distinguish it at once from common light, which has no relation to any other direction in space than that of its propagation, whereas the pencil we have supposed possesses different properties with reference to different directions *transverse* to that of its propagation. By turning the rhomb with which he was furnished into either of the two opposite positions in which the extraordinary pencil vanishes, the plane of crystalline symmetry in the rhomb would mark a plane *determined solely by the properties of the pencil of light presented for observation*, and which (as well as its rectangular plane) is a plane of symmetry in relation to those properties. The plane of crystalline symmetry passing through the normal to the face of the rhomb is evidently parallel to a line bisecting either obtuse angle of the rhombic face, and contains the crystallographic axis. *Any* plane passing through this axis in Iceland spar is called in optical language a *principal plane*, because all such planes are planes of optical, though six of them only of crystallographic, symmetry.

If our observer were further informed that the light he had been observing was the ordinary ray transmitted through a rhomb of Iceland spar, he would be able to determine the azimuth of the principal plane of that rhomb, which would be the same as the principal plane of the rhomb with which he was furnished when the latter rhomb was turned till the extraordinary pencil disappeared.

Light possessing the properties which have just been described as belonging to the ordinary ray in a rhomb of Iceland spar, however those properties may have been acquired, is said to be *polarized*, and the plane to which the properties are related as are those of the ordinary ray to the principal plane of the crystal is called the *plane of polarization*. The polarization may be detected, and the azimuth of the plane of polarization determined, by means of a rhomb of Iceland spar, as above described.

The properties of a ray which emerges after extraordinary refraction in a rhomb of Iceland spar, as may be inferred from the description given above, are absolutely identical with those of the ordinary ray, except that they are similarly related to a plane perpendicular to the principal plane. Hence the extraordinary ray is polarized in a plane perpendicular to the principal plane, the ordinary ray being, according to our definition, polarized in the principal plane.

If a piece of Iceland spar, or other doubly refracting crystal, be cut into the form of a wedge or prism, the deviation of the two rays, into which a ray incident upon it is in general divided by double refraction, will not be the same, and thus the rays will emerge in directions inclined to each other, so that their lateral separation will increase with the distance from the prism. Two such rays are still found to be polarized, and their planes of polarization to be nearly perpendicular to each other, being accurately so when the refracting edge is perpendicular to a plane of optical symmetry, or *principal plane*, of the crystal, and the refraction takes place in that plane.

For more than a century after the original discovery of Huygens, double refraction was the only phenomenon in which light was known to receive the modification called polarization. But in the year 1808, Malus made the important discovery that light receives the same modification by reflection at a certain angle from the surface of glass, water, and transparent substances in general, provided their surfaces be smooth or polished, so as to give a regular reflection. The plane of reflection was found to be the plane of polarization of light thus polarized. The angle of incidence required for complete polarization by reflection was found to vary with the nature of the substance. At an angle of incidence greater or less than this (but not reaching 0° or 90°) the same modification was imperfectly produced, the light never vanishing on rotating the analysing rhomb, but only passing through a minimum in those positions in which at the polarizing angle it vanished altogether. The simplest conception to form of the nature of light thus partially polarized is to regard it as a mixture of common light and of light polarized in the plane of incidence. The refracted light is found to be only partially polarized even at the angle of complete polarization of the reflected light, the plane of polarization being perpendicular to the plane of incidence. It may be regarded as composed of a mixture of common light and of light polarized in the plane last mentioned; and it has been found that at the same angle of incidence the quantity of light polarized in the plane of incidence contained in the reflected beam is equal to the quantity of light polarized in the perpendicular plane contained in the refracted beam. When common light is reflected from a metal, the reflected light is only partially polarized in the plane of incidence, whatever be the angle of incidence.

Shortly after Malus's discovery of the polarization of light by reflection, Sir David Brewster commenced an extensive series of experiments on the polarizing angle of a variety of media, which resulted in the discovery of the beautiful law which determines the angle of polarization, namely, that the tangent of the polarizing angle is equal to the index of refraction, which may be otherwise expressed by saying that the angle requisite for complete polarization is that for which the directions of the reflected and refracted rays are perpendicular to each other. This law embraces, as a particular case, a law which Malus had already found, that when light is incident on a plate of glass or other medium bounded by parallel surfaces at the angle required for complete polarization of the light reflected at the first surface, the refracted light is also incident on the second surface at the angle of polarization for internal reflection. Accordingly a plate of glass, or a pile of plates, may be used instead of a single surface to furnish polarized light by reflection at the proper angle, and a pile of plates has the advantage of giving light of much greater intensity than would be got from a single surface.

Certain doubly refracting crystals have the property of absorbing very unequally the oppositely polarized pencils into which they divide an incident pencil of common light. Thus certain varieties of tourmaline, cut parallel to the axis of the crystal, when of a certain thickness, absorb almost completely the ordinary ray, and transmit a great portion of the extraordinary. Hence the light transmitted by such a plate is almost perfectly polarized, in a plane perpendicular to the axis of the crystal, and the plate may be used either for procuring polarized light in the first instance, or for examining light already polarized.

The general phenomenon of the relation of the properties of a polarized beam to directions transverse to the beam may be studied very simply in the case of polarization by reflection. It is sufficient to mount two pieces of glass, blackened at the back, so that the line joining their middle points is inclined approximately at the polarizing angle (about 54° 35′) to the surface of each, and that one of them is moveable about that line as an axis. The light of the clouds is reflected from the first glass on to the second, and from thence into the eye, which must follow the light in the rotation of the glass. When the planes of reflection coincide, the light is copiously reflected, but on turning the moveable glass on its axis the intensity diminishes, until on turning to 90°, when the planes of reflection become perpendicular to each other, a dark cloud is seen about the centre of the field, the middle of which is perfectly black when the adjustments are perfect, or at least would be so with homogeneous light. The experiment may even be performed by using the light polarized by reflection from a polished table, and examining it with a bit of glass, blackened at the back, which is held in the hand. In this way the splendid colours given, as will presently be mentioned, by thin plates of selenite, &c., may be seen perfectly well, by merely holding the plate in the path of the light incident upon the moveable mirror.

In any combination consisting of a piece (suppose a pile of plates), which may be called the polarizer, destined to furnish polarized light in the first instance, and of a piece (suppose a tourmaline or a Nicol's prism), destined to examine the light furnished by the polarizer, whether modified or not in its passage to the analyzer, if the analyzer be turned till the light is extinguished, and a rhomb of Iceland spar be introduced between the polarizer and analyzer, and be turned round, the light will in general be found to be more or less restored. In two rectangular positions of the rhomb, namely, when its principal plane is parallel or perpendicular to the plane of primitive polarization (that is, the plane of polarization of the polarized light incident on the rhomb), no effect is produced, and the field remains dark. But the moment the rhomb is turned from any one of these positions the light begins to reappear, and increases in intensity till the rhomb has turned 45° from the vanishing position, after which it again decreases by the same steps.

The nature of the restoration may be analyzed by placing a screen with a small hole on the face of the rhomb by which the light enters, so as to separate the emergent pencils. As these are polarized in planes depending, not on the plane of primitive polarization, but on certain directions fixed in the rhomb, and therefore no longer perpendicular to the plane of polarization of the analyzer, they are each partially transmitted by the analyzer. If the hole be now made larger, the partially transmitted images will overlap, and if the screen be taken away altogether the light perceived must still be regarded as a mixture of two beams, the ordinary and extraordinary respectively of the rhomb, each partially transmitted by the analyzer.

When a beam of polarized light is divided into two, polarized in rectangular planes, by a rhomb of Iceland spar, the intensity of either beam was assumed by Malus to vary as the square of the cosine of the inclination of its plane of polarization to the plane of primitive polarization, a law which was afterwards verified experimentally by Arago, and which applies equally to reflection from glass at the polarizing angle, the angle between the plane of reflection from the glass and the plane of polarization of the light incident upon it being now that of which the squared cosine varies as the intensity of the reflected light. If then, in our supposed experiment, the rhomb be turned till its principal plane is inclined at an angle i to the plane of primitive polarization, and if the intensity of the incident polarized light be taken as unity, the intensities of ordinary and extraordinary beams will be expressed by $\cos^2 i$, and $\cos^2 (i+90°)$, or $\sin^2 i$, respectively. As the planes of polarization of these beams are inclined at angles $90°-i$ and i respectively to the plane of polarization of the analyzer, the fractions of the beams transmitted by the analyzer will be measured by $\sin^2 i$, $\cos^2 i$, respectively, so that the whole intensity will be measured by $\cos^2 i \sin^2 i + \sin^2 i$, $\cos^2 i$, or $\frac{1}{2} \sin^2 2i$, which vanishes when $i=0$, or $=90°$, &c., and has its maximum value $\frac{1}{2}$ when $i=45$, or $=135°$, &c.

This restoration of light which has been described in the case of Iceland spar is manifested by doubly refracting crystals in general, and forms a very simple and delicate test of the existence of double refraction, which may be applied when, from the feebleness of the doubly refracting power or the thinness of the crystalline plate, it would be difficult or impossible to make out a separation of the images. It may easily be observed by using sulphate of lime or selenite, a common mineral, which has a very perfect cleavage in one direction.

But if the plate of selenite be very thin, not so thin however but that such a plate may be readily obtained by cleavage, a new and splendid class of phenomena make their appearance, as was discovered by Arago. In those positions in which a thick plate simply restores a portion of the light, a thin plate is seen arrayed in gorgeous colours, changing with every change of thickness, and varying too when the plate is considerably inclined. If the plate be fixed, and the analyzer be made to revolve, the colours change in a remarkable manner, and when the rotation amounts to 90° the original colour at any point is replaced by its complementary, so that the two superposed make white light. This law is found to hold good for *any* two azimuths of the analyzer separated by 90°, and not merely for the azimuths 0° and 90°.

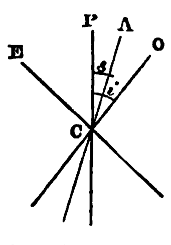
It would pass the limits of this article to describe the phenomena of the colours of crystalline plates in all their details, and the still more curious and complicated coloured rings or curves seen about the optic axis, or the two optic axes, of uniaxal or biaxal crystals. Indeed the subject has been introduced in this place only to enable the reader to form a better idea of the evidence in favour of the view taken in the undulatory theory of the nature of polarization.

The laws of the phenomena of crystalline plates were most carefully investigated by M. Biot and Sir David Brewster, and to account for them the former imagined his theory of *moveable polarization*. Dr. Young first showed that on the undulatory theory the retardation of one of the two oppositely polarized rays which passed through the crystalline plate relatively to the other was precisely that required to produce, by ordinary interference, the tint observed. Huygens's demonstration of the laws of reflection and refraction intimately connects refraction with velocity of propagation, and thereby permits of the retardation in question being calculated from the observed phenomena of double refraction, without making any assumption as to the nature of polarization. But it remained to be shown why no phenomena of interference should be perceived unless the light incident on the crystal were polarized, and the emergent light were subsequently analyzed.

It occurred to MM. Arago and Fresnel that it would be interesting to examine in what manner the interference of two rays of light, which, as regards length of path, are in a condition to interfere, might be modified by previous polarization of the rays. The memoir containing an account of this important investigation is published in the 10th volume (1819) of the 'Annales de Chimie,' p. 288, and a full account of it is given in Sir John Herschel's Treatise on Light. The laws of interference of polarized light in truth might have been obtained at once from the phenomena of the colours of crystalline plates *by assuming those colours to be due to interference*; but it was highly important at the time to establish them in a more direct manner, by the observation of what were incontestably fringes of interference. They may be thus briefly enunciated:—(1) Two rays of light coming from the same source, and polarized in rectangular planes, are incapable of interfering. (2) Two rays coming from the same source, and polarized in *the same* direction, interfere exactly like rays of common light. (3) Two rays coming from the same source of *common* light, and polarized in rectangular planes, may be afterwards analyzed without acquiring thereby the property of mutually influencing each other. (4) But two rays polarized in rectangular planes and afterwards analyzed, *do* interfere, provided they come from the same source of *polarized* light. (5) In the phenomena of interference produced by rays which have experienced double refraction, the character of the interference is not determined simply by the difference of path; it is necessary in certain cases to change this difference by a semi-undulation. The half undulation must be added or not according as the planes of primitive polarization and of analyzation lie in alternate pairs, or in the same pair of opposite quadrants made by the rectangular planes of polarization of the two polarized rays transmitted by the crystalline plate.

These laws, combined with Malus's law already mentioned, and with the formula which gives the intensity of the light resulting from the interference of two streams of light of known intensities and difference of path, enable us to calculate completely the colours of crystalline plates in polarized light without making any assumption as to what constitutes polarization.

Let C P be the plane of primitive polarization, C A that of analyzation, C O, C E the rectangular planes of polarization of the rays into which a ray of any kind is divided by the double refraction of the crystalline plate. Let i be the azimuth of C O, and s that of C A, both measured from C P. We may without loss of generality suppose i to be between the limits 0° and 90°, and s between the limits $i \mp 90°$. Further, let o, e, be the lengths of path in air equivalent in time of being described to the paths of the two rays respectively within the crystal; let λ be the wave-length in air belonging to any particular kind of light, and take the original intensity of that light as unity.



By Malus's law the intensities of the two streams, polarized along C O, C E, into which the original stream is divided by double refraction, will be $\cos^2 i$ $\sin^2 i$, respectively. If each of these be again divided into two, polarized along and perpendicularly to C A, the intensities of the former portions will by the same law be $\cos^2 i \cos^2 (i-s)$, $\sin^2 i \sin^2 (i-s)$, respectively. The difference of phase of these portions will be $\frac{2\pi}{\lambda}(o-e)$. Now if I, I′ be the intensities of two streams of common light from the same source, ρ their difference of phase, the intensity of the light resulting from their interference will be $I + I' + 2\sqrt{(I I')} \cos \rho$. But by the second law of interference of polarized light this formula may be applied to the interference of two streams of polarized light which are capable of interfering, as by law 4 the two streams are which are polarized along C A. In the application of the formula we must take $\sqrt{I} = \cos i \cos (i-s)$, $\sqrt{I'} = \sin i \sin (i-s)$ or $= \sin i \sin (s-i)$, according as $i > s$ or $i < s$. But by law 5 when $i < s$ we must change the actual difference of path by half an undulation, that is, change ρ by π, or, which comes to the same, change the sign of one of the radicals $\sqrt{I}$ or $\sqrt{I'}$. Hence it will suffice to take $\sqrt{I'} = \sin i \sin (i-s)$ in all cases, and omit the addition or subtraction of the half undulation. Hence the expression for the intensity will become

$$\cos^2 i \cos^2 (i-s) + \sin^2 i \sin^2 (i-s)$$
$$+ 2 \cos i \sin i \cos (i-s) \sin (i-s) \cos \frac{2\pi}{\lambda}(o-e) \quad . \quad . \quad . \quad . \quad . \quad . \quad (A)$$

which may be readily transformed into the more simple expression

$$\cos^2 s - \sin 2i \sin 2(i-s) \sin^2 \frac{\pi}{\lambda}(o-e) \quad . \quad . \quad (B)$$

The discussion of either of these expressions would give account of the observed phenomena of the coloration of crystalline plates in polarized light; but would exceed our limits. Suffice it to remark that in the expression (B) the first term denotes the illumination, alike for all colours, which would exist if the plate were removed, while the second changes materially from colour to colour, in consequence of the variation of λ, in comparison of which the variation of $o-e$ may usually be neglected.

Now the study of the phenomena of light which are independent of polarization leads us, and that in different ways, to the conclusion that with light of given wave length the square of the amplitude of vibration must be taken as the measure of intensity, and consequently the amplitude of vibration will vary as the square root of the intensity. If now, bearing this in mind, we go over the whole investigation of the colours of crystalline plates, beginning with the first application of Malus's law, and deducing at every step from the intensities which are the objects of direct observation the corresponding amplitudes of vibration, we can hardly fail to be impressed with the idea that in polarized light the vibrations of the ether take place in a rectilinear manner in a direction *transverse* to that of propagation, and related in some constant manner to the plane of polarization. Unquestionably there must be a transverse *something* about polarized light which admits of composition and resolution in that way. Now polarized light in all its relations is symmetrical with respect to the plane of polarization and the perpendicular plane, and to no other. For example, when light is polarized by reflection at the surface of glass, everything must evidently be symmetrical with respect to the plane of reflection. Hence our rectilinear vibrations must also be symmetrical with respect to the plane of polarization, and therefore must either be in or perpendicular to that plane.

But if such be the nature of polarized light, what notion must we form of the nature of common light? We have seen that common light, in passing through a rhomb of Iceland spar not limited by a screen, is resolved into two polarized streams, which, mixing on emergence, yield a light having all the properties of common light. Nor does the light reflected from the first surface of the rhomb possess any other properties: it may be polarized like common light, or divided by another rhomb into two polarized streams which mix on emergence just as before, so that there is not the slightest ground for supposing that with the light lost by reflection the original beam loses any element of a different character from that which it retains. It is easy to make out the nature of the vibration which results from the co-existence of two series of rectilinear and transverse vibrations propagated in the same direction and taking place in rectangular planes. The vibrations in such a case would take place in planes perpendicular to the direction of propagation, that is, would lie in the fronts of the waves.

Hence the following important suppositions are adopted in the theory of undulations.

The vibrations of the ether which constitute light, unlike those of air which constitute sound, take place, not to and fro in the direction of propagation, but laterally in the tangent planes of the waves. In polarized light the vibrations are rectilinear, and either parallel or perpendicular to the plane of polarization, a point which for the present may be left undecided. *The polarization of common light consists in the resolution of the vibrations into two rectilinear series, the undulations belonging to one of which are obtained apart from those belonging to the other.*

The theory of transversal vibrations was first suggested by Dr. Young, who was led to it by the consideration of certain phenomena of biaxal crystals discovered by Sir David Brewster. It suggested itself independently to the mind of Fresnel, who was led to it by considering the laws of interference of polarized light, made out by Arago and himself. It encountered, at first, much opposition, for it was entirely opposed to preconceived notions. It obliges us in fact to suppose that the vibrations which constitute light are carried on, not by forces by which the ether tends to resist condensation or rarefaction, but by forces by which it tends to resist *distortion*, unaccompanied by change of volume. We are driven to conceive that a sliding motion of the ether, layer over layer, is resisted by a tangential force thereby called into play: in fact, to treat the ether, so far as the vibrations of light are concerned, as if it were an elastic solid. Still, it would ill accord with the spirit of inductive philosophy to reject a conclusion to which we are fairly led by the study of observed phenomena, because it clashes with preconceived notions respecting the nature of a medium of the very existence of which we have no evidence beyond the beautiful and simple explanation it affords of the curious and complicated phenomena of light.

If once we adopt the theory of transversal vibrations, we are able not only to form a clear picture in the mind of what, to say the least, polarization *may* be, but to explain in the simplest manner both Malus's law and the laws of interference of polarized light. In fact, Malus's law and laws 2, 4, 5, of interference led to the theory of transversal vibrations; and to explain these laws on the theory we have only to begin at the other end. Laws 1 and 3, which assert the necessity of a polarizer in order that any colours should be seen in crystalline plates, follow at once from the consideration that the rectangular components of the vibrations in common light have no fixed and permanent relation to each other, either as to phase or amplitude, so that they are *as good as* the vibrations belonging to two streams from different sources.

The theory of transversal vibrations, again, enables us to form a perfectly clear notion of the nature of a peculiar modification of light, known as elliptic polarization. When polarized light is transmitted across a crystalline plate, the emergent light is in general elliptically polarized, being only in particular cases polarized in the way hitherto considered in this article, or *plane-polarized*, as it is called in contradistinction to elliptic polarization. When elliptically polarized light is examined by an analyzer which is made to revolve, the light never wholly vanishes, but becomes alternately a maximum and a minimum at every quarter revolution. Thus far it agrees with partially polarized light, from which, however, it wholly differs in other respects, both theoretically and experimentally. [Elliptic Polarization.]

Lastly, the theory of transversal vibrations is, to say the least, very hopeful in its application to the explanation of double refraction, of the polarization of light by reflection, &c. The full explanation of these phenomena is retarded by two causes, first, there are the inherent mathematical difficulties of the problem, and secondly, which is far worse, in our ignorance of the ultimate constitution of matter, and its relation to the luminiferous ether, we have to grope in the dark in our endeavour to find out what is the real state of things to which our mathematics have to be applied. Still, even in this department many important laws have already been explained, and frequently even predicted, on dynamical principles, though not always with perfect rigour; but no dynamical theory has yet accumulated in its favour such a weight of evidence as to exclude others, nor can even the question whether the vibrations of polarized light are parallel or perpendicular to the plane of polarization be yet considered settled, though the probability seems to be in favour of the latter view, which was that originally adopted by Fresnel.

In this article the subject of double refraction has not been touched except so far as was necessary for the explanation of polarization. For further information on this point see a subsequent article, Undulatory Theory.

POLARIZATION, MOVEABLE. This term refers to an ingenious theory by which M. Biot attempted to explain the colours of crystalline plates in polarized light. The theory is, however, liable to some formidable objections; and as the phenomena have since been explained in the most simple and complete manner on the theory of undulations [Polarization] the reader who wishes for further information on this subject is referred to M. Biot's original paper in the 13th volume of the 'Mémoires de l'Institut.'

POLARIZED RINGS. The beautiful coloured rings or curves seen with polarized light about the optic axis or axes of doubly refracting crystals. [Undulatory Theory.]

Q

Q is a superfluous letter of the alphabet, having the same sound as *k*, though limited to words where a *u* follows. This letter furnishes evidence that the alphabetical characters were originally of syllabic power. Thus the Hebrew koph and the Greek koppa appear to have been used only in those words where the sound of *o* follows, as in Cos, Corinth, and Syracosii, &c. Indeed the name of the letter implies as much. The Greek alphabet probably stopped at one period like the Hebrew, at *τ*, so as to have no *u*. On the other hand, the Etruscan alphabet had a *u*, but no *o*. Hence in Italy, the *q*, which, by position in the alphabet, corresponds to the Greek koppa, was limited to words where a *u* followed. In the same way the kaph of the Hebrew and kappa of the Greek were probably at first limited to those words where an *a* follows, as we know was the case in Latin; and as the modern name of the letter, *ka*, denotes, for it would otherwise have been called *ke* or *ek*. This view becomes more complete if it be called to mind that the name of *χ* connects it with the vowel *i*; and that the *η* or H of the Greek alphabet was originally a guttural aspirate, sounded perhaps as *χη*, and thus was adopted to denote either a guttural consonant or a long *e*. For the various forms of the symbol *q* see Alphabet, and for the changes to which the letter is liable see C and K.

QUADI, an ancient people of Germany, who inhabited the country north of the Danube, between that river, the mountains of Bohemia, and the river March. Towards the north they bordered on the Marcomanni, in connection with whom they are frequently mentioned by the Roman writers as allies. Tacitus ('German.,' 42) mentions the Quadi, the Marcomanni, and the Narisci as being in the foremost rank among the German nations towards the borders of the Roman empire, the Danube forming the line of demarcation between the power of Rome and German independence. At a later period the Quadi joined a great confederacy of German nations against Rome, which occasioned much alarm to the empire, and which twice obliged the emperor Marcus Aurelius Antoninus to repair to Germany at the head of his legions. They are afterwards mentioned by Eutropius as having invaded Pannonia in the reign of Gallienus.

QUADRANGLE and QUADRILATERAL (four-angled and four sided). These terms are indiscriminately used to denote a figure with four sides in the same plane. [Parallelogram; Rectangle; Square; Trapezium; Rhombus.]

QUADRANT. [Sextant.]

QUADRANT. As an astronomical instrument, the quadrant has within a few years been so completely superseded by the entire circle, that it will not be worth while to describe particularly its construction or adjustments. Still so much of the very groundwork of modern astronomy depends on data furnished by the quadrant, that it cannot be properly passed over without some notice.

We have already said [Circle] that the earliest form of instrument for measuring celestial altitudes was also the best, namely, the solstitial or meridian circle described by Ptolemy. After showing how the proportion which the arc between the tropics bears to the whole circumference was to be determined by this instrument, Ptolemy proceeds to say ('Amalgest,' book i., chap. 10), "We have made this sort of observation more conveniently by using, instead of circles, a stout quadrangular block of wood or stone, having one side plane and smooth. Upon this side we described a fourth part of a circle from a centre near one of the angles, and having drawn from the centre two radii including a right angle, we divided the circumference into ninety degrees with subdivisions. We then inserted two perfectly equal cylinders at the extremities of the vertical radius, so as to be exactly concentric with the centre and extreme point, and set the block vertical by a plumb-line passing over the cylinders, and also in the plane of the meridian by a north and south line described on the horizontal plane. We observed at noon the shadow of the central cylinder, having applied something to the divided arc to show the place more clearly, and, marking the middle point, we took the corresponding division of the quadrant as showing the elevation of the sun on the meridian." It would seem that on the revival of learning, when Ptolemy was thought infallible, the quadrant came into use on this authority, to the exclusion of the circle. In the 'Astronomiæ Instauratæ Mechanica' of Tycho Brahé, figures and descriptions will be found of quadrants and sextants of various forms and sizes. We do not think justice is done at the present day to the merits of Tycho, who is better known as the perplexer of the Copernican hypothesis, than as the first great practical astronomer after Hipparchus. Among his numerous instruments Tycho had a large quadrant fixed on a wall, which he calls a *mural* quadrant, with which he observed meridian altitudes, noting the time of transit by a clock. There are several other quadrants figured and described, which revolve on a vertical axis, and some have a horizontal circle by which the azimuth was observed at the same time with the altitude. These may be considered as the precursors of the modern astronomical quadrant, and still more perfect altitude and azimuth instrument, just as his mural quadrant led to the mural arc of Flamsteed, the mural quadrants of Bird and Ramsden, and finally to the mural circle of Troughton. The imperfection of his clocks (for the pendulum was not applied till nearly a century later) compelled Tycho to adopt an instrument which has long been out of use. This was his astronomical *sextant*, which was stronger, more convenient, and lighter than the quadrant. It was supported at the centre of gravity on a ball and hemispherical cup, and could consequently be easily placed in the plane passing through two stars, and so used for measuring their distance from each other. To verify the value of the arc, and to test the powers of his sextants and quadrants, the distances of a chain of stars near the equator were taken, and their declinations also observed, when it was found that the sum of the angles at the pole which resulted from observation was 360° very nearly. (Tycho Brahé, 'Astronomiæ Instauratæ Progymnasmata,' pp. 138, 145.)

Hevelius has described his quadrants and sextants in the first volume of his 'Machina Cœlestis,' a work which is not uncommon; the second volume, containing his observations, was burnt soon after it was printed, with the exception of a few copies, and is one of the scarcest and dearest astronomical books in existence. In the convenience of his instruments, and perhaps in the accuracy of their graduation, he surpassed Tycho, but he never could understand the advantage of telescopic over plain sights, though one of the best practical opticians and industrious star-gazers of his time. This unfortunate prejudice not only rendered the labour of his long life labour in vain, but embittered his latter years to a painful degree by involving him in a dispute with Hooke.

Picart, aided, as it is said, by Auzout, first applied telescopic sights to graduated instruments. In his measure of the earth, executed in 1669 and 1670, he used a quadrant for his terrestrial angles. This he has described, with figures, in a special work, printed at the Louvre, which became so rare that the 'Académie Royale des Sciences' reprinted it in their Memoirs (vol. vii., part i., p. 133). The quadrant was of 38 inches radius, with one telescope fixed in the direction of one radius, and the other moveable about the centre; the arc of the instrument was divided by transversals, and the angle read off by the index of the moveable telescope was equal to the angle subtended at the quadrant by the objects bisected by the cross-wires of the two telescopes. The instrument could be fixed on its stand with the plane vertical when used for altitudes, and by an additional piece, a *genou*, was moveable into any other plane, when it was wanted for surveying. The whole turned on a vertical axis, like Tycho's azimuthal quadrants, but without an azimuthal circle. Quadrants like Picart's continued to be made by the French artists and used by their astronomers (with some improvements, of course) up to the latter end of the last century, when they were superseded by the repeating circle of Borda. The verification of the arc and of the graduation was performed in Tycho's manner, only employing well defined objects in the horizon instead of stars.

For a fixed observatory Picart and Roëmer recommended a large quadrant permanently fixed, that is, a copy of Tycho's mural quadrant, with the changes which telescopic sights required. Lemonnier, in the preface to his 'Histoire Céleste,' says that La Hire had one erected in the Royal Observatory at Paris, in 1683, and that it was described in the first edition of La Hire's tables. This description he repeats at page xlii. of his work.

Flamsteed made his earlier observations at Greenwich with a sector, the plan of which may be understood by conceiving one of Tycho's sextants with telescopes, instead of plain sights, to be mounted on a polar axis. ('Historia Cœlestis,' vol. iii., p. 103.) This instrument was designed for measuring the distances of stars from each other. But in pursuing his primary object, that of settling the places of the fixed stars with accuracy, Flamsteed found that he required a *meridian* instrument. Some unlucky trials at constructing a quadrant were made by the person employed by the Royal Society, and Flamsteed finally constructed, at his own expense, and by Abraham Sharp's hands, the mural arc with which he observed from 1689 to his death.[*] (See the description and figure, 'Historia Cœlestis,' vol. iii., p. 108.) This differed from other mural arcs chiefly in this, that it contained 140° or 150°, so that all stars were observable with it, from Polaris, below the pole, to the south horizon. The arc was placed as nearly in the meridian as might be, and the errors in its plane detected by comparing the observed time of the sun's passage over the middle wire of the instrument, with the true time of his meridian passage, as deduced from corresponding altitudes with a quadrant. The pendulum clock, though as yet not a very perfect instrument, had by this time entirely done away with the necessity of observing the mutual distances of the stars.

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[*] Among the *real* injuries which Flamsteed received, we consider the translation of his preface into indifferent Latin one of the greatest, though committed with a friendly intention.

When Halley succeeded Flamsteed at Greenwich, the observatory appears to have been dismantled. Halley saw the great superiority of Roëmer's *transit* over every other instrument for ascertaining right ascension, and accordingly introduced it; but he seems not to have perceived the advantages which Roëmer's *circulus meridionalis* possessed over any segment of a circle. In 1725 a mural quadrant was erected by Graham, which was superior to any previous instrument of this construction; it had however one grievous imperfection: the radii being of iron and the arc of brass, every variation of temperature altered the value of the total arc. In 1750, this quadrant, which was subsequently known by the name of the iron or north quadrant, was removed to the other side of the pier, and the celebrated quadrant by Bird set up in its place. Of Bird's method of dividing we have given some account in the article GRADUATION. His reputation, which was a good deal based on this quadrant, introduced similar instruments by himself or Ramsden into almost every observatory of note. Bird received 500*l.* from the commissioners of longitude for his 'Method of dividing Astronomical Instruments,' and the work was published by their order in 1767. We are not aware that a more perfect quadrant than the Greenwich *brass* or *south* quadrant was ever constructed. It was with this instrument Bradley made his invaluable observations, which have been reduced with consummate skill by Bessel. ('Fundamenta Astronomiæ deducta ex Observationibus viri incomparabilis James Bradley, autore F. W. Bessel, Regiomonti,' 1818.) There is in this work a careful examination of the errors to which the two quadrants were liable.

When the portable quadrant was wanted for astronomical purposes, the plane was fixed vertically, and it is then usually called an astronomical quadrant. A great many instruments of this construction were made by Bird, Ramsden, and the Troughtons, in the latter half of the last century, and in careful hands a great deal of work may be done with such a quadrant.[*] Thus observations of the sun or stars at the same altitude on each side of the meridian will furnish an excellent determination of the time, and zenith distances of stars near the zenith in reversed positions of the instrument (the excess arc, as it is called, affords the means) will yield a good latitude. Observations of northern stars combined with southern stars at similar altitudes will give a very close approximation to the latitude when the true places of the stars are taken from a good catalogue. For the mode of adjusting and using the quadrant we must refer to the older books or encyclopædias which treat of astronomical instruments. The inferiority of the quadrant to the entire circle is such that there is no probability of its ever returning into fashion, and we believe there is not a single public observatory in which it is now in use. The single advantage of the quadrant is that the divisions are larger and consequently more easily read and subdivided than in a circle with the same telescope. But this trifling superiority is much more than compensated by the power of reading off the circle at several points and taking the mean. On the other hand it is impossible in the quadrant to secure the exactness of the total arc, or the concentricity of the centre of motion and the centre of the divisions, while the necessity of leaving some liberty of motion to the axis carrying the telescope allows of a little wandering of the centre-work, which is perpetually shifting its place. Thus it was found that in the celebrated Greenwich quadrant, though the error of division was probably not more than 1″, the uncertainty arising from other causes might easily be 3″ or even more. Again, in the mural quadrant it seems difficult so to support it as to resist the long continued effort of gravity in altering its form, without at the same time rendering it unstable. The Greenwich quadrant was found to have sensibly altered its shape, that is, it had become flattened about 45°, and pulled out at the two extreme radii, which was shown by the errors in the places of stars observed by it when compared with their places by circular instruments, and also by an actual measurement of the several radii and chords. For more minute information the reader is referred to Lalande's *Astronomie*, § 2311, &c., 3me. edition; Vince's *Practical Astronomy*, chapter v.

QUADRANT. Halley's quadrant is the name sometimes applied to the octant of reflexion which measures an angle of 90°. The principle is that of the SEXTANT.

QUADRANTAL, a name formerly given to a spherical triangle one side of which is a quadrant.

QUADRATIC, BIQUADRATIC (*quadratum*, a square), names given to algebraic expressions, the highest powers of which are the square, and the square of the square, or fourth power, of the letter with reference to which the expressions are considered. [THEORY OF EQUATIONS.]

QUADRA'TRIX, a name given to curves which may be made useful in the QUADRATURE of other curves. There is one known by the name of Dinostratus, the equation of which is—

$$y = (a - x)\ \text{tan.}\left(\frac{x}{a}\ 90^\circ\right),$$

which curve being given, the ordinate, when $x = a$, determines the length of the circle whose radius is a, as follows:—Make a rectangle on this ordinate equal to the square of the diameter, and the other side of that rectangle is the circumference of the circle.

The quadratrix of Tschirnhausen has for its equation—

$$y = a \sin\left(\frac{x}{a}\ 90^\circ\right),$$

and this curve being given, and also the method of drawing a tangent to it, the circumference of a circle may be thus found: Draw a tangent at the origin, and draw a right-angled triangle with a part of this tangent for the hypothenuse, and a part of the axis for a base: the other side is then the quadrant of a circle which has the base for a radius.

Various other modes might be found of making either of these curves square the circle; but the fact is, that the description of the curves themselves assumes the point which their use is to determine.

QUADRATURE. By the quadrature of a curve is meant the finding of a square equal to the content inclosed by the curve; but as every rectilinear figure can be immediately converted into a square of equal magnitude, the object is gained so soon as *any* rectilinear figure is found of the same content as the curve. This is the geometrical quadrature of a curve. The arithmetical quadrature is the determination of the area inclosed by the curve in terms of a given square unit, as a square foot; and if this be done with any required amount of accuracy, the quadrature, thus done sufficiently for practical purposes, is spoken of as an absolute quadrature. The two following articles will in various places illustrate the preceding description of the meaning of the simple word.

QUADRATURE OF THE CIRCLE. The speculative part of this question might be passed over with a slight description of the means of finding a square equal to a given circle, or of expressing a circle by means of the square on its radius, if it were not that it is connected with one of those propensities, the love of the marvellous, which, carried to an undue extent, tend more than others to throw the mind off its balance, and destroy the comfort of the individual. When it is considered that there are still persons who spend their time, means, and energies in the attempt to overcome a difficulty of which they do not even know the character, it is worth while to enter a little more at length upon this celebrated question of the quadrature of the circle than its mathematical importance would seem to require. We may add that its historical importance is very great.

It is a proposition not very difficult of proof, that if a right-angled triangle have the radius of a circle for its base, and a line equal to the circumference for its altitude, the triangle is equiareal with the circle. Hence the quadrature is reduced to the finding a line equal in length to the circumference, either geometrically or arithmetically; or to finding an answer to one or other of the following questions:—

Given a, the diameter of a circle in units of a given kind, required a number or fraction π, such that a multiplied by π may be the number of those same units in the circumference. It is easily shown that this number π must be the same for all circles.

Given the diameter of a circle, required *geometrically* a method of drawing a straight line equal in length to the circumference.

Those who first proposed these questions found their progress arrested by the insufficiency of their arithmetic and the limitations of their geometry. The former question has long been settled, and it has been shown that the ratio of the circumference to the diameter is INCOMMENSURABLE. The latter question cannot be called finally settled, since there is no proof in which all agree that the *geometrical* quadrature is impossible, though there are considerations which render it in the highest degree unlikely, and there are also asserted proofs of the impossibility which some admit, and which make even those who do not absolutely admit them think their conclusion all but proved. But the mistake of those who produce pretended quadratures often lies in this, that they do not know what is meant by the word *geometrical*. They imagine that anything is geometrical which deals in notions about space, and deduces that which is not obvious from that which is. But geometry, in the technical sense, is that which results from the use of Euclid's postulates [AXIOM], which permit nothing but the junction of two points by a straight line, the indefinite production of that joining line, and the description of a circle with a given centre, and the line joining that centre with another given point as a radius. These limitations make the whole difficulty; otherwise nothing would be more easy than to determine a circle by the QUADRATRIX, if that were allowed to be drawn, or to suppose a circle to roll on a straight line till the point which first touched the straight line touches it again, in which case the line rolled over is the length of the circumference. When, therefore, any one imagines, as is often the case, that he has found a method of squaring the circle, it generally happens that he only announces the not very new nor surprising fact, that a difficulty which exists under certain circumstances may be no difficulty at all under others. But in like manner as no one would be held likely to answer the question "Required the way of building a house without the use of iron," who should first demand a common hammer and nails, so the greater number of persons who attempt to square the circle must not be supposed to meet the geometrical difficulty by assuming powers of which geometry expressly requires the use to be abandoned, until it can be shown to be given in allowing the simple postulates above mentioned.

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[*] A very perfect specimen of the astronomical quadrant is described in Pearson's 'Astronomical Instruments,' vol. ii., p. 554.

Aristophanes introduces into his comedy of the Birds a geometer who is going to make a square circle. Plutarch asserts that Anaxagoras employed himself upon this problem in prison. Hippocrates of Chios actually found the way to make a rectilinear space equal to certain circular spaces, and is reported to have attempted the general problem. There is evidence enough that it acquired an early celebrity, and it may be doubted whether the researches of Euclid in incommensurables [Irrational Quantities] had not some reference to a supposition that the circle and its diameter might possibly be discovered to belong to a particular class of these quantities. Archimedes, in his book on the mensuration of the circle, is the first who made any approach even to a practical determination of the question. By inscribing and circumscribing polygons of 96 sides in and about the circle, he demonstrates that the excess of the circumference over three times the diameter must be less than 10-70ths of the diameter, and greater than 10-71st parts. His limits are perfectly correct, and even tolerably close. According to him, a circle of 4970 feet diameter would have a circumference lying between 15,610 and 15,620 feet, the truth being that such a circle would have a circumference of 15,613$\frac{3}{4}$ feet very nearly. This measure of Archimedes gives 3·14286 for the approximate value of π, the ratio of the circumference to the diameter; several of the Greeks are said to have made further approximation, but their results are not preserved.

Among the Hindus [Viga Ganita, in Biog. Div.] are found the ratios of 3927 to 1250, and also that of the square root of 10 to 1. The first gives $\pi=3{\cdot}1416$ exactly, and is considerably more correct than that of Archimedes; the second gives 3·1623, and is much less exact. The date of the first result is not known; but all agree that the writings in which it is found are anterior to any European improvement on the measure of Archimedes. The ratio given by Ptolemy, in the Syntaxis, is 3·141552, not quite so correct as 3·1416, but so near to it that those who doubt of the antiquity of Hindu science will probably suppose the 3·1416 above mentioned to be a version of Ptolemy's measure.

This subject began to be reconsidered in the 16th century, in the middle of which were calculated the tables [Tables] of Rheticus, the celebrated Copernican, from which the value of π might easily have been calculated to eight decimals, but it does not appear that this was done. Purbach used the ratio of 377 to 120, or 3·141667, not so exact as Ptolemy's. Regiomontanus slightly corrected the limits of Archimedes, but Peter Metius, father of Adrian (to whom it is often attributed, merely because Adrian records and delivers it), and of James (to whom the invention of the telescope has been given), made a decided improvement. He gives the ratio of 355 to 113, or 3·14159292, which is correct to the sixth decimal inclusive. Nothing more precise could be desired for practical purposes, insomuch that a circle of 113 in diameter may be reckoned as one of 355 in circumference, which, though a little too great, does not give the circumference wrongly by so much as one foot in 1900 miles. On looking, however, at the account which Adrian Metius gives of his father's investigation, we find that the extreme closeness of the approximation is only a piece of good fortune. As it is very curious that this should never have been noticed, we quote the whole passage:—"Parens meus Illustrium D.D. Ordinum Confœdaratarum Belgiæ Provinciarum Geometra, in libello quem conscripsit adversum quadraturam circuli Simonis à Quercu demonstravit proportionem peripheriæ ad suam diametrum esse minorem quam $3\frac{17}{120}$, hoc est $\frac{377}{120}$, majorem vero quam $3\frac{15}{106}$, hoc est $\frac{333}{106}$, quarum proportionum intermedia existit $3\frac{16}{113}$, sive $\frac{355}{113}$. Quæ quidem intermedia proportio aliquantulum existit major, quam ea, quam invenit Mr. Ludolph à Collen, cujus tamen differentia est minus quam $\frac{1}{1000000}$." The book of Peter Metius was never published, that we can find; and we doubt if Adrian Metius would have published his father's result, if it had not come so very near to the then recent result of Van Ceulen. It seems that the elder Metius, finding $\frac{17}{120}$ too great, and $\frac{15}{106}$ too small, took the mean of the numerators for a numerator, and the mean of the denominators for a denominator, and presumed that the result was nearer the truth than either limit: a presumption to which he had no right whatever, except that of trusting to the chapter of accidents.

Metius lived in the latter half of the 16th century, as also did Vieta, who gave a still more accurate though not so elegant a measure. He was the first who exhibited a series of arithmetical operations by which a mere calculator might carry on the process to any extent, and gave the following result: The circle whose diameter is ten thousand million of parts, has a circumference greater than 31,415,926,535 of those parts, and less than 31,415,926,537. Other approximations rapidly followed: Adrianus Romanus calculated the perimeter of an inscribed polygon of 1073741824 sides, by means of which he found for the ratio 3·141592653589793; but his contemporary Ludolph van Ceulen, by calculating the chords of successive arcs, each of which is the half of the preceding, found the perimeter of a polygon of 36893488147419103232 sides, and obtained 36 figures of the ratio 3·14159, &c., presently given to a still greater length. So far the method of calculating by means of inscribed polygons, though Vieta had reduced it to routine, had received no material simplification. This was given by Snell, who found some propositions (afterwards demonstrated by Huyghens) which very much abridge the labour. He found a result as correct as that of Archimedes, by means of a simple hexagon; making the 96-sided polygon of Archimedes give seven decimals correctly, instead of three. He also calculated the ratio to 55 decimal places, and by means of a polygon of only 5242880 sides. Huyghens introduced some new theorems of the same species as those of Snell.

The invention and cultivation of the differential calculus led to many new views and new methods, into which it is not our purpose to enter, as we intend the present article not for mathematicians, but for those who have just enough of the science to think it possible that the solution of the problem is reserved for them. The continued product of Wallis, the continued fraction of Brounker, the series of Mercator, Gregory, Newton, &c., were so many new algebraical expressions of a result which, one might imagine, would be considered as carried far enough by the arithmetician. Nevertheless the ratio was consecutively carried to 75 places by Abraham Sharp, to 100 by Machin, and to 128 places by De Lagny, and at the end of the last century to 140 places by Vega. And Baron Zach gave Montucla the copy of a manuscript * in the Radcliffe Library at Oxford, in which it was carried to 154 places.

Vega's result, which, so far as they go, is confirmed by those of Machin and De Lagny, is wrong only in the last four figures. The Oxford manuscript is wrong only in the last two.

In the year (1841) in which this article was first published, Dr. Rutherford communicated to the Royal Society 208 places of decimals. Of these, however, it was afterwards found that the last 56 were incorrect; and so, it was found, were the last two figures of the Oxford result: that is, the Oxford manuscript and Dr. Rutherford were correct just as far as they agreed. About 1846, Mr. Dase [Tables], a very powerful mental calculator, calculated 200 decimals; and in 1847, Dr. Clausen, of Dorpat, calculated 250 decimals, by two methods. ('Astr. Nachr,' No. 489, according to Mr. Shanks.) In 1851, without being aware of what Dr. Clausen had done, Mr. William Shanks [Tables], of Houghton-le-Spring, Durham, calculated 315 decimals, which Dr. Rutherford verified, and extended to 350 decimals. In 1851-52, Mr. Shanks extended his calculation to 527 decimals, while Dr. Rutherford independently calculated 441. In March and April, 1853, while Mr. Shanks was passing a very full account of his 527 figures through the press, he extended it to 607 decimals, and gave the result in 'Contributions to Mathematics,' London, 1853, 8vo. Accordingly, this famous result is now certainly obtained to 441 decimals, and with high probability to 607.

We give Mr. Shanks's result, and also his values of the base of Napier's logarithms, and of the modulus of Briggs's system; three numbers which are often wanted together. The figures between the rules, and those in the lowest row, are to enable the reader to detect and correct any error of printing, or to decide upon any defaced figure. The number between the rules is the sum of the ten preceding digits; and the number in the lowest column is the unit's figure of the sum of the whole column. Thus 1415926535 has digits which sum into 41; and 1584447730952 has digits which sum into 59, of which the 9 is written below.

$\pi=3\cdot$

1415926535	41	8979323846	59	2643383279	47	5028841971	45	6939937510	52
5820974944	52	5923078164	45	0628620899	50	8628034825	46	3421170679	40
8214808651	43	3282306647	41	0938446095	48	5058223172	35	5359408128	45
4811174502	33	8410270193	35	8521105559	41	6446229489	54	5493038196	48
4428810975	48	6659334461	47	2847564823	49	3786783165	54	2712019091	32
4564856692	55	3460348610	35	4543266482	44	1339360726	40	0249141273	33
7245870066	45	0631558817	44	4881520920	39	9628292540	47	9171536436	45
7892590360	49	0113305305	21	4882046652	45	1384146951	42	9415116094	40
3305727036	36	5759591953	58	0921861173	38	8193261179	47	3105118548	36
0744623798	50	3474956735	53	1885752724	49	8912279381	50	8301194912	38
9833673362	50	4419366430	40	8602139501	35	6092448077	47	2309436285	42
5309662027	40	5569397986	67	9502224749	44	9620607497	50	0304123669	34
2913382± &c.									
9143465303		0128272607		2758486206		9554953223		2428876161	

$e=2\cdot$

7182818284	49	5904523536	42	0287471352	39	6624977572	55	4709369995	61
9574966967	68	6277240766	47	3035354759	44	4571382178	46	5251664274	42
2746639193	50	2003059921	31	8174135966	50	2904357290	41	0334295260	34
5956307381	47	3232862794	46	3490763233	40	8298807482	56	0707673049	43
39492 + &c.									
6187800315		6806574807		4776518190		0287303212		9981781368	

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* On making inquiry at the Radcliffe Library, we find that no such thing is known to be there, nor has been known for the last forty years at least. The inquiry has often been made, and every search has been unproductive. Baron Zach must certainly have seen such a manuscript somewhere: for, though fond of a hoax among friends, it is incredible that he should have *correctly* calculated the result sixteen places further than had been done, merely to make Montucla believe in an Oxford manuscript. Montucla does not say that Zach saw any manuscript upon the subject: but only that he saw the result *in a manuscript*. It may be that the figures were only jotted down on a fly-leaf, or something of that sort: if not, Zach must have failed to remember *where* he saw the figures; a thing in itself very unlikely.

M = .

4342944819	48	0325182765	39	1128918916	46	6050822943	39	9700580366	44
6566114454	42	0842952103	34	2056138938	45	8912264709	48	6695346114	45
2004339380	32	5647056134	41	3122302306	22	0442927744	43	1521725473	37
7266818420	53	0167232947	41	0756458650	46	6129322975	46	5024684291	41
56499 ±&c.									
4607095962		5861212839		6942796790		0423225251		1830125034	

These excesses of calculation are useful in showing the way, and in destroying that belief in the impracticability of extending what has been done which has retarded the progress of many subjects. The 607 decimal places give no sufficient notion of their amount of accuracy; or rather, give no sufficient notion of the impossibility of placing the amount of accuracy before the imagination. But the following illustration has a tendency to do what is wanted.

The blood-globules of some animalcules are a millionth of an inch in diameter. Let there be an inhabited globe so large that our great globe is but fit to be a blood-globule in the body of one of its animalcules; and call this the first globe *above us*. Let the *second* globe above us be so large that the *first* globe is but as one of the blood-globules in it; and so on to the *twentieth* globe above us. Next, let one of the blood-globules on our globe be an inhabited globe, with everything in proportion; and let this be the first globe *below us*. Let the *second* globe below us be but a blood-globule in an animalcule of the *first;* and so on to the twentieth globe below us. Then if the inhabitants of the twentieth globe above us were to calculate the circumference of their globe from its diameter by help of the 607 decimals, the inhabitants of the twentieth globe below us could not detect the error with their best microscopes, unless their Tulleys and Rosses were much greater masters of their art than ours.

The newest attempt at quadrature of our century is that of Mr. R. Ambrose Smith, of Aberdeen. It was undertaken as a test of the theory of probabilities. If a thin rod, not so long as the breadth of a plank, be thrown at hazard upon a planked floor, the chance which the rod has of intersecting a seam between two planks is the fraction which the length of the rod is of the quadrant having the breadth of a plank for its radius. In 3204 tosses with a rod three-fifths of the breadth of plank, the experimenter found 11 mere contacts, and 1213 decided intersections. He counted the contacts as intersections, and, from the principle [PROBABILITY] that the result of a large number of trials is nearly that of the long run, he presumed that 3 is to the quadrant of radius 5 nearly as 1224 to 3204. This gives 3·1412 for the ratio of the circumference to the diameter; which comes nearer than Archimedes. If, which perhaps ought to have been done, the contacts had been equally divided between intersections and non-intersections, the result would have been 3·1553 : and even this is a remarkable approach, the nature of the method being considered.

The never-ending character of these numerals, so far as they were tried, led to an early suspicion that the ratio must be really incommensurable. This was actually proved by Lambert ('Mém. Acad. Berlin' for 1761), and the demonstration has been given in an abridged form by Legendre, in the notes to his work on geometry. This demonstration is perfectly complete, and leaves no manner of doubt on the subject. Those who persist in asserting that they can assign two numbers which are in the ratio of the circumference to the diameter, should first learn geometry and algebra enough to refute this proof, for they may depend upon it that no mathematician will lend them a moment's attention until this preliminary step has been taken. Buffon, and Panckouke, the editor of the 'Encyclopédie Méthodique,' have attempted to give metaphysical reasons for this incommensurability, apparently in order that the squarers of the circle might not have all the nonsense on their side of the question.

Proof of the impossibility of the *geometrical* quadrature, as above described, was attempted by James Gregory, in 1668; and Montucla seems to admit the proof at last,* though he only said that it was *very like demonstration* in the first edition of his work on the history of this problem. The objections made by Huyghens to this proof, and the controversy which ensued, obliged Huyghens to admit that Gregory had succeeded in proving the impossibility of what is called the indefinite quadrature of the circle, by which is meant the finding of a method of squaring any given sector of the circle whatsoever. But since it is well known that there are curves, particular portions of which may be squared, this may happen in the case of the circle. Thus it might be possible to give a geometrical rule for squaring the whole circle, even though the rule would not apply to every given sector. The proposition which Gregory imagines himself to prove, is that no sector of a circle can have to the circumscribed polygon a ratio expressible by a finite number of algebraical terms. The consequence of this, if established, must be drawn as follows:—Since geometry allows the use of nothing but definite circles and straight lines, a straight line equal to the circle in length (which being found, the whole difficulty is overcome) must be ascertained, if at all, by a construction in which points are successively determined by the intersections of straight lines or circles, or a straight line and a circle. The most complicated construction in Euclid may, if we begin from the first principles, be reduced to the determination of a succession of points in this manner. Now, in the most complicated case of the intersection of two circles of given or found radii and centres, the points of intersection may be determined by formulæ derived from the roots of an equation not exceeding the second degree, the roots of which can be expressed in a finite form: the two ends of the line equal to the circle could therefore be assigned in a finite form, and hence the length itself. And the area of any polygon (whose arcs are obtained by continual bisection) described about a given circle could also be expressed in a finite form, from which (the area of the circle being expressible by means of its circumference) the ratio of the area to that of the circumscribed polygon would also be expressible. But if Gregory's proposition be true, this area cannot be expressed in a finite form; neither then can any construction allowable in geometry attain the circumference of a circle.

The indefinite quadrature was shown to be impossible by Newton (Principia, book i., lemma 28), in a manner which lies open to solid objection; we shall not therefore produce this proof. In fact, it seems as difficult to induce geometers to agree in any proof of the impossibility of the indefinite quadrature, as others to leave off trying their powers upon what geometers themselves have ceased to attempt.

Montucla has given a tolerable list of those who have signalised themselves by attempting this problem without the requisite preliminary of studying geometry; if preliminary that may be called, which would have made them give up the attempt. We shall presently mention some of them; but first we have a list of those who were, most of them mathematicians, or, if not, known in other things. "Only prove to me that it is impossible," said some one, "and I will set about it immediately," and such seems to have been the general feeling of the quadrators, as Montucla calls them. They existed in crowds in the time of Archimedes; and the race is not yet extinct. One Bryso, a Greek, heads the list: he made the circle a mean proportional between the inscribed and circumscribed squares, which happens to be the content of the inscribed octagon. Next we have Cardinal Cusa, Orontius Fineus, and Simon à Quercu, or Duchesne, already mentioned. At the time when the problem really was of practical importance, every quadrator raised up an opposing mathematician; and the quadrature was sometimes so ingenious, and so near the truth, that it could only be opposed by new approximations to the truth. Thus Cusa was met by Regiomontanus, Orontius by Buteo and Nonius, and Duchesne by Peter Metius, who (it is said) was compelled to discover the very close approximation we have given under his name by that of Archimedes being insufficient to expose Duchesne. But independently of what we have already said about Metius, it is not true that Duchesne's quadrature required any new accuracy of limits to expose it. He produced 3·14660...: and Archimedes had already shown that 3·14285.... was too great. Quadrators whose results forced further investigation were of use, and if some of them would now arise, no one would object to fallacies so ingenious that new truths must be discovered to oppose them. The celebrated Joseph Scaliger, a mere tyro in geometry, tried his hand on this and other problems in 1592, and was met by Vieta, Adrianus Romanus, and Clavius. Longomontanus, the astronomer (refuted by Pell), J. B. Porta, and Hobbes (refuted by Wallis), are three names well known in other pursuits who must go down to posterity as having had distinguished success in false quadrature. The works of the last against geometry and geometers were the consequence of the mortification he felt at not having been admitted to have succeeded in his attempt. Before his time however, Gregory St. Vincent, an acute mathematician (to whom is due the discovery of the connection between the hyperbolic area and logarithms), had made the most elaborate attempt which ever was published, in his work on the quadrature of the circle (Antwerp, 1647). Such a challenger raised up Des Cartes, Roberval, Huyghens, and Léotaud, who soon despatched him.

As yet we have mentioned only mathematicians, or men of eminence in something: but we have also the Spaniard Falcon (1589), who dialogues with the circle in verse: Gephirauder and Alphonso de Molina, who attribute their discovery to inspiration; the latter overturns Euclid, and found another who was willing to admit his discoveries and translate them into Latin. A merchant in Rochelle, De la Leu, not only found out the problem by inspiration, but showed that the conversion of Jews, Turks, and Pagans depended upon it. Montucla gives some account of several other visionaries, the chief of whom is one Cluver, who found that the problem depended upon another, namely, "Construere mundum divinæ menti analogum," which, if it be translateable, is, "to make a world analogous to the divine mind." He also mentions Richard White, an English Jesuit, who stands out among the solvers of the problem as the only one who ever was convinced of his error. The writer of this article once pointed out the example of White to another Roman Catholic clergyman, who had come from South America to England, to publish a quadrature of the circle. The party addressed seemed struck by the instance, and promised to study more geometry before he proceeded further; in a little while however he relapsed, and his work was advertised, and, we believe, published.

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* The following was the addition left by him, and printed by the editor of the second edition: "Après avoir réfléchi encore plus attentivement sur les raisonnements de Gregory, il me paraît avoir eu raison d'en déduire l'impossibilité de la quadrature même définie du cercle." For ourselves, we left off unable to dispute, but feeling the insecurity which attaches to almost all negative proofs. We thought it as convincing as Abel's proof of the impossibility of algebraic solution of the fifth degree, as that proof stood in Abel's own memoir.

After the time of Newton, and the abundant means which were then introduced to complete the quadrature, if such a thing were possible, persons versed in mathematics seem to have dropped the attempt, and the reign of the quadrators by instinct commences. It is true that a serious diversion was made by the theory of gravitation, which drew off against itself many of those who should have been quadrators; but enough remained to furnish a tolerable list.

That of Montucla contains principally Frenchmen, though had the history of mathematics been written by an Englishman, he could have produced as great a number in this country. One Mathulon, in 1728, promised in print 1000 crowns to any one who should convict his solution of error, and was actually sentenced by the courts to pay the sum to the Hôtel Dieu at Lyon, to which charity Nicole, the exposer, made over his claim. One Sullamar (as Montucla spells it), an Englishman, solved the problem by means of the number of the beast, 666, in the year 1750; a M. de Causans, in 1753, found it by cutting a piece of turf, and deduced from it the doctrines of original sin and of the Trinity. He offered to bet 300,000 francs on the correctness of his process, and deposited 10,000, which were claimed by several persons, and among others by a young lady, who brought an action for them: but the bet was declared void by the courts. Many more cases might be added; it is however enough to say that this problem is now never attempted (in print at least), except by those who are either altogether ignorant of mathematics, or add a most undue opinion of themselves to an acquaintance with only the elements. Since 1755, the Academy of Sciences has refused to examine any pretended solution; and the Royal Society in this country came to the same resolution a few years afterwards. In the announcement of their determination, the French Academy, without pronouncing any dictum upon the problem, stated that in a period of seventy years, those who had brought forward quadratures had been persons who did not know the nature of the difficulty of the problem. An experience of about half that time has satisfied us that the same thing may be said of our own day: and with this addition, that whereas the speculators who came before the Academy seem for the most part to have had an idea that their chance, if any, lay in the *geometrical* quadrature, the squarers of our time, in nine cases out of ten, announce the *arithmetical* quadrature, which has been proved to be impossible.

A few words may serve to prevent some one from making an attempt upon this enchanted castle, as it is supposed to be. When the difficulty first began to be noticed, the circle stood alone among curves; and so remarkable a distinction between this, the only curve then considered, and rectilinear figures, the only other figures then considered, could not but excite curiosity. Our position is now changed; not only does the now well recognised distinction of commensurable and incommensurable prevent the circle from presenting anything peculiar to itself, but the curve is only one among an infinitely great number, many of which have been investigated and their properties examined. Consequently, with reference to the present state of mathematics, the problem analogous to that of squaring the circle is, "Given any curve whatsoever, to find its area." Now if the ingenuity which is guided by the love of investigating hidden things, should desire a field for its exertions, let it leave that of the circle, which has been cropped until it will yield no more, and, first acquiring sufficient mathematical knowledge, let it spend its force upon some one of the many real difficulties which abound, both in the pure and mixed sciences: let it investigate the meaning of divergent series for example, in all their varieties, or endeavour to extend the theory of discontinuous expressions, or solve the equations of motion of the solar system by some other method than that of series. For one point that should strike the lover of the marvellous in the quadrature of the circle, there are hundreds in the above-named subjects which surprise the mathematician, however little he may possess that quality. Moreover, in like manner as the quadrature of the circle was at one time, in the hands of Wallis, Newton, &c., a road to results which, though they did not attain their end, yet answered many other purposes; so the efforts of the inquisitive on the actual difficulties of our own day may also end in the promotion of science of every kind, if begun in knowledge and directed by system. We owe the binomial theorem, now one of the most important results of algebra, indirectly to the learned attempts of Wallis upon the quadrature of the circle, at a time when such attempts were in season: and we might reasonably hope for collateral successes something like those resulting from the labours of Wallis, if those (not a few) whose minds compel them to inquiry into the curious, would but furnish themselves with a guide before they set out on their travels.

This problem still engages attention: and persons are found to believe that they have attained even the arithmetical quadrature. And it is a peculiarity of this well-worn old problem, that it catches the fancy of those who have not even attended to common geometry, and frequently makes them think that the riddle is reserved for *them* to read. And the reason is, that they treat it as a riddle: a thing to be thought out by some sudden stroke of mother-wit. They do not know that there are thousands of problems of the same kind in everything but notoriety. Thirty years ago, when the 'Penny Magazine' was young, it contained an article on this subject which might have been thought sufficient at least to establish the fact of a difficulty. A man of high rank and great wealth, who had probably never opened a book of geometry since his school days, if even then, happened to read this article, was caught, and in five minutes produced an idea which he thought so likely to be the solution of the enigma, as he would have it to be, that he forwarded it to the secretary of the Useful Knowledge Society, for transmission to the author of the article.

It has been stated in foreign newspapers within these few years that the British government does offer, and always has offered, a large reward for the solution of this problem. This, we need hardly say, is a complete mistake: the government never at any time offered one farthing for the quadrature of the circle. Some years ago, a labouring man from the country came to town with a quadrature, and addressed a letter to the Lord Chancellor, stating his claim, and desiring his lordship to hand over forthwith 100,000*l.*, being the sum due from government for the discovery, as per proclamation: this letter we saw. The only problem for the solution of which any reward was at any time offered, was the practical mode of finding longitude: and even this offer is now retracted; rewards having been, in fact, received by several persons. Should this article fall into the hands of any, at home or abroad, who are working at any mathematical or astronomical difficulty under the impression that our government is pledged to remunerate them in case of success, they may rest assured that their information is incorrect, and that they will find it to be so on inquiry. The only person we know of who states definitely what the reward is, and by whom offered, is Nicolas Ericius, in a tract on the quadrature "Fundamentalis figura geometrica ...." Copenhagen, 1755. The author states, as known to all, that on the 2nd of June, 1747, the Royal Society of London publicly advertised a reward of 30,000*l.* for the quadrature of the circle and the discovery of the true nature of the magnet, over and above some previously offered sum, the amount of which is not stated. It is needless to say that the archives of the Royal Society contain no account of any offer of the kind.

Persons who are not acquainted with the subject are puzzled by one consideration, which we admit is calculated to have weight. The quadrators appeal to great discoveries which have at last been recognised, though their promulgators were at first treated with contempt. We pass over the last part of the assertion with the remark that Copernicus, Galileo, Tycho Brahé, Harvey, &c., were never treated with *contempt*: some were opposed, some were persecuted, and all were ridiculed by a section of their opponents; for ridicule is a constituent of all opposition whatsoever, though not from every opponent. But those with whom Copernicus, &c., came in contact, whether in person or in book, showed amply that they knew what manner of men they had to deal with. The more important point is the following. Invention in mechanics may have been sometimes attained—not very often—by men who were ignorant of the doings of their predecessors. But discovery in matters of speculation—that is, conquest over old and tried difficulties—has never, that we have read of, been reached by any one whose mind had not been trained by study of previous speculation. All the men we have mentioned, and all of their stamp that we know of, were *learned* men, acquainted with the history of the subject they were destined to advance, and practised in its methods: they had all shown their power over what *was* known, before they presented themselves as the promulgators of what *was not*. The squarer of the circle, therefore, may be asked to show proof of his acquaintance with the previous history of the subject: any one who really does this would, even now, meet with some attention. But the general run of circle-squarers are as ignorant of the past as the future will be of them.

Again, we have to meet the very plausible objection, that many difficulties have been overcome at last: why not then the quadrature of the circle? The answer is easy. The difficulties which have been overcome at last have been overcome by the discovery of new means, and the introduction of new powers; but our problem is to square the circle with the *old allowance of means*: Euclid's postulates and nothing more. We cannot remember an instance in which a question to be solved by a *definite method* was tried for centuries by the best heads, and answered at last, *by that method*, after thousands of complete failures.

QUADRATURES, METHOD OF. The method of quadratures derives its name from its earliest application, that of finding the areas of curves, which was always called their quadrature, as being the arithmetical process by which, when exact, squares equal to them might be found. And since the AREA of a curve can always be found when $\int y dx$ can be found, this term has also been applied to the determination of the definite values of integrals by approximation. We shall first complete the reference in OFFSET. An area being bounded by a curve, a part of the axis, and two extreme ordinates, if the base on the axis be divided into any number of equal parts by ordinates (offsets), the chords which join the ends of successive offsets, if substituted for the arcs of the curve, will give very nearly the same area. And this area is found by adding half the first and last offset to the sum of all the intermediates, and multiplying by the common base. This is the old surveyor's rule. Thomas Simpson gave one of more exactness, by drawing a parabola, of axis perpendicular to the base, through the first, second, and third points, another through the third, fourth, and fifth, and so on, the number of equal parts being *even*. The approximate area is then found by adding to the first and last offset twice the sum of all the other odd ones and four times the sum of all the even ones, and multiplying the sum so obtained by the third part of the common base, or smallest subdivision of the whole base. The following method gives any required amount of approximation. Any integral [INTEGRATION] can be found approximately by a summation, the limit of which is the exact value: thus we could determine $\int x dx$ from $x=a$ to $x=a+h$ by dividing h into a large number, n, of equal parts, and actually summing

$$a.\frac{h}{n} + \left(a+\frac{h}{n}\right)\frac{h}{n} + \left(a+2\frac{h}{n}\right)\frac{h}{n} + \dots + \left(a+n\frac{h}{n}\right)\frac{h}{n}$$

but the special object of that which is called *the* method of quadratures is the perfection of this method of quadratures (which is either very inexact or very tedious) by subsequent corrections, which are most readily derived from such mathematical considerations as are described in the article OPERATION. The theorem on which it is founded may be seen in p. 313 of the 'Differential Calculus,' in the 'Library of Useful Knowledge:' exhibited in the best form for practical use, it is as follows:—

Let $\int y dx$ be required to be found from $x=a$ to $x=a+h$: divide h into n equal parts, and let $A_0, A_1, A_2 \dots A_n$ be the values of y corresponding to the following values of x, namely, a, $a+\frac{h}{n}$, $a+2\frac{h}{n}$, … $a+n\frac{h}{n}$ (or $a+h$). Compute

$$S=(A_0+A_1+A_2+\dots+A_n)\frac{h}{n}$$

And, writing down A_0, A_1, &c., as below, take their differences. [DIFFERENCE.]

$$\begin{array}{l}
A_0 \quad A_1 \quad A_2 \quad A_3 \dots\dots\dots A_{n-3} \quad A_{n-2} \quad A_{n-1} \quad A_n \\
\quad \Delta A_0 \; \Delta A_1 \; \Delta A_2 \dots\dots\dots \Delta A_{n-3} \; \Delta A_{n-2} \; \Delta A_{n-1} \\
\qquad \Delta^2 A_0 \; \Delta^2 A_1 \dots\dots\dots \Delta^2 A_{n-3} \; \Delta^2 A_{n-2} \\
\qquad\quad \Delta^3 A_0 \qquad \dots\dots\dots \qquad \Delta^3 A_{n-3}
\end{array}$$

up to the fifth differences, which will be generally sufficient. Then the value of $\int y dx$ from $x=a$ to $x=a+h$ is as follows, very nearly:—

$$S-\frac{1}{2}\frac{h}{n}(A_n+A_0)-\frac{1}{12}\frac{h}{n}(\Delta A_{n-1}-\Delta A_0)-$$
$$\frac{1}{24}\frac{h}{n}(\Delta^2 A_{n-2}+\Delta^2 A_0)-\frac{19}{720}\frac{h}{n}(\Delta A_{n-3}-\Delta^3 A_0)-$$
$$\frac{3}{160}\frac{h}{n}(\Delta^4 A_{n-4}+\Delta^4 A_0)-\frac{863}{60480}\frac{h}{n}(\Delta^5 A_{n-5}-\Delta^5 A_0)$$

For example, let the integral required be $\int\frac{dx}{x}$ from $x=9$ to $x=13$ (we take purposely a case in which verification is easy.) Here $a=9$, $h=4$, $y=1:x$. Divide the interval 4 into ten equal parts, so that $h:n=·4$. We have then 9, 9·4, 9·8, …. 12·6, 13, for the eleven values of x, and writing down their reciprocals, and taking their differences, we have

	A=	ΔA= −·00	Δ²A= +·000	Δ³A= −·0000	Δ⁴A= +·00000	Δ⁵A= −·00000
0	·11111111	472813	38597	4541	685	122
1	10638298	434216	34056	3856	563	103
2	10204082	400160	30200	3293	460	076
3	09803922	369960	26907	2833	384	061
4	09433962	343053	24074	2449	323	054
5	09090909	318979	21625	2126	269	041
6	08771930	297354	19499	1857	228	
7	08474576	277855	17642	1629		
8	08196721	260213	16013			
9	07936508	244200				
10	07692308					

S 1·01354327 × ·4 = ·40541731

$$\begin{array}{rclcll}
A_{10} & + & A_0 & = ·18803419 & \times \frac{1}{2} \times ·4 = & ·03760684 \\
\Delta A_9 & - & \Delta A_0 & = ·00228613 & \times \frac{1}{12} \times ·4 = & ·00007620 \\
\Delta^2 A_8 & + & \Delta^2 A_0 & = ·00054610 & \times \frac{1}{24} \times ·4 = & ·00000910 \\
\Delta^3 A_7 & - & \Delta^3 A_0 & = ·00002912 & \times \frac{19}{720} \times ·4 = & ·00000081 \\
\Delta^4 A_6 & + & \Delta^4 A_0 & = ·00000918 & \times \frac{3}{160} \times ·4 = & ·00000007 \\
 & & & & & \overline{·03769252} \\
 & & & & & ·40541731
\end{array}$$

$$\text{Approximate value of } \int_9^{13}\frac{dx}{x} = \overline{·36772479}$$

The same result, found by common methods, is hyp. log. 13 — hyp. log. 9, or 2·56494936 — 2·19722458, or ·36772478: so that the preceding method is in this case more than correct to seven figures by use of four differences.

This method of quadratures is the mathematician's last resource when all others fail or are still longer. In most of the cases in which it is absolutely requisite, the calculation of the values of y is the most tedious part of the operation. When the limits are very different, it is generally requisite to divide their interval into several parts, and to make the integrations through the several parts separately. For an inverse process see SUMMATION.

QUADRICHLORACETAMIDE, or *Chloracetamic acid* $\left(C_4HCl_3NO_2 = N\left\{\begin{array}{l}H\\ Cl\\ C_4Cl_3O_2\end{array}\right.\right)$, is a product of the action of chlorine upon trichloracetamide. It occurs in colourless, inodorous, acicular prisms, of disagreeable taste.

QUADRICHLOROBUTYRIC ACID. [BUTYRIC ACID.]

QUÆSTOR (from *quæro*: "*qui conquireret publicas pecunias et maleficia*," Varro, 'De Ling. Lat.,' iv. 14) is a name which was common to two distinct classes of officers at Rome, who were only distinguished from each other by different attributes: the name of one class was *quæstores parricidii*; that of the other, *quæstores classici*.

It is said by some that the office of *quæstores parricidii* existed even in the reigns of Romulus and Numa. Livy (i. 26) and Tacitus ('Annal.,' xi. 22) think that they were appointed by the kings; but it is more probable that the kings only proposed the candidates, and that they were appointed by the populus. (Ulpian, 'De offic. Quæst.,' 'Dig.,' i. 13.) That the office existed in the reign of Tullus Hostilius is certain, and the general opinion among the Romans was that it was instituted by that king. After the establishment of the republic, the two quæstores parricidii continued to be elected in the comitia of the curies, on the presentation of the consuls, as they were before on that of the kings; but they were now regularly elected every year, whereas before they had only been appointed in cases of emergency. After the decemvirate, they were elected by the centuries. At the time of the Licinian law one part of their functions was swallowed up by the office of the triumviri capitales, while the rest were embodied in the offices of the curule ædiles and the tribunes.

The *quæstores parricidii*, according to Niebuhr, were the same as the *duumviri perduellionis*, but Walter ('Gesch. des Röm. Rechts,' p. 855) has adduced a number of passages which seem clearly to prove that the *quæstores parricidii* must be distinguished from the *duumviri perduellionis*, who continued to be elected to the end of the republic, and were real judges in cases of perduellio. The quæstores, on the other hand, were a kind of public accusers, who conducted the accusation and carried the sentence into execution. (Festus, s. v. 'Parici;' Dionys. Hal., viii. 78.)

The *quæstores classici* had the superintendence of the public treasury, and are said to have been instituted by Valerius Publicola, who gave the right of electing them to the populus, though Wachsmuth ('Geschichte des Römisches Staats') contends that there was only one kind of quæstor. At first they were only two in number, and in the year 421 B.C. their number was doubled (Liv., iv. 43.) and part of them were to be plebeians, but this was not the case until ten years afterwards, when three out of the four quæstores were plebeians. (Livy, iv. 43, 54.) From the time that four quæstores were elected, two accompanied the consuls into the field, while the two others remained in the city (quæstores urbani). After the Romans had made themselves masters of all Italy (489 B.C.), the number of quæstores was again doubled, so that there were now eight of them (Liv., 'Epit.,' lib. xv.), for the administration of the financial affairs in the city, in the army, in Italy, and the province of Sicily. One of them, who resided at Ostia, had also to provide the city with corn. (Cic., 'pro Sext.,' 17.) Sulla in his dictatorship raised their number to twenty, and Cæsar to forty. (Tacit., 'Annal.,' l. c.; Dion Cass., xliii. 47, 51.) During the time of the emperors their number varied. The two quæstores urbani, down to the time of Julius Cæsar, had the administration of the public treasury; they registered the revenue and expenditure of the republic (Ascon. Ped. on Cic., 'in Verr.,' ii. 1 p. 158, ed. Orelli; Plut., 'Cat. Min.,' 17, 18), received the money due to the state, and made the payments sanctioned by the senate. They had also to receive and take under their especial protection all foreign ambassadors, and those strangers who were connected with the state by ties of public hospitality; finally they had the care of the funerals and monuments which the senate decreed as distinctions for men of great merit (Plut., 'Quæst. Rom.,' 43; Val. Max., v. 1., 1.; Cic., 'pro Flacco,' 18): they kept in the treasury the books in which the senatus consulta were copied, until Augustus also entrusted them with the keeping of the original documents. (Dion Cass., liv. 36.) Julius Cæsar transferred the administration of the treasury from the quæstores to two ædiles. (Dion Cass., xliii. 47.)

The military quæstores who accompanied the consuls into the field (Cic., 'in Verr.,' ii. 1. 15) had the charge of the money with which the war was carried on, distributed among the soldiers their provisions and pay, and superintended the sale of the booty, the produce of which was either divided among the soldiers or lodged in the public treasury. (Livy, iv. 53.) They had however to give in an account of all their proceedings to the treasury. (Cic., 'in Verr.,' ii. l. 14; and Ascon. Ped., p. 167, ed. Orelli.)

With the extension of the Roman empire, a greater number of quæstores was required for the financial administration of the conquered countries and the provinces, and it was chiefly owing to this that their number increased in proportion as the empire became greater. The prætor was therefore usually accompanied in his province by a quæstor, who had the whole financial department under his control, but was, like the other quæstores, accountable to the treasury; in case of his death, the prætor appointed a pro-quæstor in his stead. (Cic., 'in Verr.,' ii. l. 15.) When the prætor was absent from his province, the quæstor usually supplied his place, and was then attended by lictors. (Cic., 'ad Fam.,' ii. 15; 'pro Planc.,' 41.) There seems to be no doubt that the quæstors at all times, after the year of their office was over, had a right to take their seat in the senate; of Sulla it is expressly said that he raised their number to twenty, for the purpose of filling up the vacancies in the senate.

In the time of the emperors we have mention of some quæstors who bore the title of Candidati principis, and who were not sent into provinces, but had only to read in the senate the communications which the emperor had to make to that assembly. From the time of the emperor Claudius it became customary for quæstores, on entering upon their office, to give gladiatorial spectacles to the people, and accordingly none but the wealthiest Romans could aspire to the office.

The quæstores, in the provinces of the Populus Romanus, had the jurisdictio of the curule ædiles, and consequently the right of promulgating edicts. No edicts were promulgated in the provinces of the Cæsar. (Gaius, i. 6.)

C. W. Göttling's 'Geschichte der Römischen Staatsverfassung,' 1840, may also be consulted, and W. A. Becker's 'Handbuch der Römischen Alterthümer,' 1843-56.

QUAKERS, the name first given "in scorn," and since habitually, to the sect of Christians who call themselves the "Society of Friends." [Fox, George, in Biog. Div.]

Origin.—The founder, or rather the first member of this society was George Fox, who towards the middle of the 17th century, after long wanderings about the country and much spiritual conflict and inquiry into the merits of the sects then raging against each other in England, separated himself from all, feeling that "none could speak to his condition." By degrees his religious opinions assumed a distinct form, and in the year 1647, when he was 23 years of age, he commenced his ministry by preaching at Dukinfield near Manchester. In a short time the number of believers in his doctrines increased; in 1648 large meetings attended his ministry in Nottinghamshire, and, notwithstanding cruel persecution, the society spread from the poor and uninstructed to many of the more opulent and educated classes.

It is not our intention to describe the process by which George Fox was led to adopt his peculiar opinions, or the course of conduct which these induced him, whilst yet a very young man, to pursue. Such a narrative might cast on the sect an air of extravagance, which belongs less to this body in particular than to the period of religious excitement in which it had its rise. Notwithstanding instances of indiscretion or enthusiasm in some of its first members, the early history of the society is full of examples of undaunted courage in passive and ultimately successful resistance to oppression.

Tenets.—The Society of Friends have no articles of creed, subscription to which is required of their members. Their principal tenets may however be gathered from the writings of George Fox, William Penn, and Robert Barclay, and their other approved authors, and from the minutes and epistles issued by their yearly meeting in London to the subordinate meetings.

They believe that it is the prerogative of God alone to declare himself to man; and therefore they prefer expressing their religious opinions in the language of Holy Scripture. In full accordance with these sacred writings, they have ever believed that there is one God and Father of all, of whom are all things; that there is one Lord Jesus Christ, by whom all things were made, who was glorified with the Father before the world was, who is over all, God blessed for ever; that there is one Holy Spirit, the promise of the Father and the Son, the Leader, Sanctifier, and Comforter of his people: and that these three are one God. Whilst objecting to scholastic terms and distinctions, and to all attempts to be wise in the deep things of God, beyond what He has plainly revealed, they have ever professed their belief in the real manhood as well as the true deity of our Lord and Saviour Jesus Christ; that the Word which was in the beginning with God, and was God, was made flesh and dwelt amongst men. They maintain that man in the fall is separated and alienated in his nature from God; that all have sinned and come short of the glory of God, and are therefore exposed to divine wrath; and that it is solely through the mercy of God in Christ Jesus that any are brought into reconciliation with him; receiving remission of sins through faith in the one propitiatory offering of the Lamb of God, and sanctification of heart through the influences of the Holy Spirit. They believe the Holy Scriptures to be given by inspiration of God, and to be profitable for doctrine, for reproof, for correction, for instruction in righteousness; and they have always professed their entire readiness that their tenets and practices should be tried thereby

But that which may be regarded as the doctrine mainly distinguishing them from other Christians, is what they apprehend to be a fuller recognition both of the universality and of the teaching of the Holy Spirit. They believe that the light of the spirit of Christ does in measure enlighten every man that cometh into the world; that the effects of the death of Christ are coextensive with those of Adam's transgression, according to the declaration of the Apostle, "As in Adam all die, even so in Christ shall all be made alive;" and, as a consequence hereof, that even those who have not the outward knowledge of the Gospel history may, by giving heed to their measure of this light, become partakers of that salvation which comes by Jesus Christ.

They moreover believe that the guidance of the Holy Spirit is to be experienced by every sincere believer in Christ, in reference both to his religious duties and to his daily walk in life,—that to be guided by the Spirit is the practical application of the Christian religion. They also maintain that this manifestation of the Spirit, given to every man to profit withal, is the only essential qualification of the Christian for service in the church, and is independent of human choice or appointment. They hold it to be the prerogative of Christ to call and qualify by the Holy Spirit his servants to minister in word and doctrine, and that, as in the earliest period of the Christian church, this Spirit was poured upon servants and upon handmaidens, so he continues to call from *women* as well as from men, from the young and from the old, from the unlearned and from the poor, from the wise and from the rich, those whom he commissions to declare unto others the way of salvation. As such have freely received the gift of the ministry, so are they freely to give without hire or bargaining, far less to use it as a trade to get money by. Hence they refuse the payment of tithes and all other ecclesiastical imposts. They believe that the true worship of God is offered in the inward and immediate moving and drawing of his own Spirit; and that all other worship, beginning and ending in man's pleasure, ought to be rejected. Hence they abstain from the use of all prescribed forms of prayer, and refuse to observe appointed days of thanksgiving, or of fasting and humiliation. They believe that as all the types and shadows and ordinances of the law were fulfilled in Christ, so he established no new ordinances to be administered or to be observed in his church, that his baptism is that of the Holy Ghost and of fire, that he himself is the bread of life, and that the communion of his body and blood is inward and spiritual, and that in thus partaking of the substance, the figures are no longer needed. They assert that as God hath assumed to himself the dominion of conscience, all punishment for conscience sake is therefore contrary to the truth; provided that no man under the pretence of conscience prejudice his neighbour. They believe that true religion delivers man from the spirit and vain conversation of this world, and leads him to inward communion with God; and that hence all foolish and superstitious formalities and all frivolous recreations ought to be rejected: thus all public rejoicings are disapproved of.

Friends deem the taking of all oaths unlawful, and much of their sufferings arose from the firmness with which in former days they refused the oaths often wantonly tendered to them. They believe too that all wars and fightings are inconsistent with pure Christianity, and they refuse all participation directly or indirectly in them. They believe marriage to be a divine ordinance, but in their marriages they do not use the intervention of a minister, for whose interference they allege that there is no Scripture warrant. When any of the Society intend to marry, they acquaint their respective men's and women's meetings of their intentions, and the necessary inquiries having been made as to the consent of parents, the freedom of the parties from all previous engagements, and, if the woman is a widow with children, as to the security of a due provision for these, the parties in a public meeting for worship solemnly take each other in marriage, and a certificate of the fact is given to them. Friends abstain from all pomp in the burial of their dead and from the use of mourning apparel or of grave-stones. They do not use the heathen names of the days or months, but designate them by their numbers; and they object to address an individual in the plural number, or by his title of courtesy, or by any designation which they consider as either inconsistent with Christian truthfulness, or as irreverent or merely complimentary; but they have no scruple against the use of the simple names of dignity or office.

Discipline.—The discipline of the society was at least indicated and to a great extent established by George Fox with much foresight; for notwithstanding the great increase of the body and the altered circumstances of the times, the system has been found adequate to the protection and the government of the society.

The members of one or more congregations (according to their size) hold monthly meetings for looking to the orderly conversation of the members, for taking care of their poor (a duty which the society rigidly fulfils to the superseding of all parochial relief), for regulating the proceedings in relation to marriage, and for other matters affecting the well-being of the body.

There are quarterly meetings throughout the nation, to which representatives are sent from the subordinate monthly meetings. There are also monthly and quarterly meetings of women Friends similarly constituted.

There are meetings for worship on Sunday, and in the forenoon of one other day in the week. The epistle from the yearly meeting in 1675 exhorts Friends not to decline, forsake, or remove their public assemblies because of times of suffering; for such practices are not consistent with the nobility of truth.

Finally, there is a yearly meeting of representatives from all churches of the society throughout Great Britain and Ireland. This meeting is held in London on the Wednesday after the third Sunday in May, and remains sitting many days. It receives reports of the state of the particular churches, and it issues to them a general epistle. A similar representative body or yearly meeting of women Friends is held at the same time for the general supervision of the religious state of those of their own sex, but they have no power to make rules for the government of the body. During the intervals of the yearly meeting, the general business of the society is conducted by a meeting termed the Meeting for Sufferings, which is a carefully selected standing committee of the yearly meeting. There is a general fund belonging to the society, called the national stock; it is formed by the voluntary contributions of members, and it is applied to the publication of religious works, the expenses attending applications for legislative relief in cases of suffering, the payment of the expenses of ministers travelling in foreign parts out of the limits of any meeting, and other public objects of the society.

Whilst it is the duty of the individual members of the society generally to watch over one another in love, this duty is more especially confided to certain officers of each sex in the respective meetings, who are called overseers, and who, whenever any case of delinquency comes to their knowledge, visit the individual privately, and labour with him in tenderness with a view to his restoration; but if these efforts prove unavailing, they are to bring the case to the monthly meeting, which appoints a committee to exercise further care in reference to it; and if all attempts at reclaiming the offender should fail, he is disowned as a member of the society by a document issued by the monthly meeting and signed by its clerk.

There are many wise provisions made by the society for exercising care over those who believe themselves called to the work of the ministry. This care is more especially entrusted to the elders, who are persons chosen for their spiritual discernment, and from having given evidence by their fruits of the soundness of their faith. The eventual recognition or acknowledgment of ministers as such rests however with the monthly meeting at large, including all the men and women members of the congregation. Monthly meetings are cautioned not hastily to give certificates of competence to those who desire to travel in the ministry; but to take care that these are well approved at home, are of sound doctrine, of good conversation, and in unity with their own meetings.

This notice of the Society of Friends ought not to be closed without honourable mention of their constant efforts in the cause of humanity. The Lancasterian system of instruction has found among Friends some of its most zealous supporters; they also early opposed the slave trade, and in 1761 members engaged in the slave-trade were disowned. Latterly there has been a growing tendency to modify the distinctive peculiarities of dress and speech, and the desire for a certain amount of conformity to the innocuous habits of ordinary society has received the formal sanction of the annual meeting. For some time there have been symptoms of a decrease of numbers of the sect, and in 1859 prizes were offered for the best essay on the causes of such decline and the means of remedying them.

('Rules of Discipline for the Religious Society of Friends,' London, 1834; Sewel's 'History of the People called Quakers,' London, 1834; Barclay's 'Apology,' (the edition used for this article is that of 1701, London); and 'Memoir of the Life of George Fox,' 1839; also the articles Fox, Barclay, Penn, and Gurney, in the Biog. Div.)

QUALITY (from the Latin *qualis*), in the common acceptation, comprises all attributes that can be given to a thing, with the exception of those of magnitude and quantity, and it matters not whether the attributes are essential to the thing or merely accidental. But in speaking of the qualities of things, we chiefly consider those by which they are distinct from other and similar things. This circumstance accounts for some expressions, such as "a man or a person of quality," in which the word quality is used synonymously with rank, as *the* quality by which in aristocratical countries one class of men is distinguished from all others.

Among the ten categories or fundamental notions of the philosophy of Aristotle, quality is the third; but Kant, who has reduced the ten categories of Aristotle to four, makes quality the second; and according to him it comprises the notions of existence, non-existence, and limitation; or of reality, negation, and limitation; that is to say, all things which come within the sphere of man's thought are, in the category of quality, either something or nothing, or something of which he can only say what it is not. In logic, affirmation and negation are the qualities of a *proposition*.

QUALITY OF ESTATES, QUANTITY OF ESTATES. [Property.]

QUANTITY. There is little here to add to what has been said in the article Magnitude, so far as the mathematical notion is concerned. The quantity of anything is the answer to *quantus?* (how much?) and the considerations under Ratio are necessary to the precise answer. Mr. Mill, in his 'Elements of the Human Mind,' has invented the word *tantity*, since *quantus* (how much) is answered by *tantus* (so much); and he therefore uses quantity and tantity as correlative words. But in truth the meaning of *quantity*, as generally received, does not refer to the question, but to the answer: so that the word *tantity*, if introduced, could only mean the same thing as quantity, unless the meaning of the latter word were changed. If any one were to propose that quantity should signify what it does at present, with the addition of a reference to seeking, requiring, or asking, and that tantity should involve the same notion, its object being considered as found, given, or determined, undoubtedly the proposition would be a good one, considered apart from the difficulty of altering established meanings. The word *quantuplicity*, as distinguished from quantity, means the answer to how *many times*, as distinguished from how much. [Ratio.]

The notion attached to the word quantity in the middle ages varied between two extremes. At one end it signified the abstract idea of that about which *quantus* can be asked: and in this sense it necessitated the startling maxim that "quantity does not admit of more and less." Thus we have not more right to say of a mile than of a foot that it is the proper subject of the question *quantus*, or has *quantitas*. At the other end, quantity was a "thing which is *per se* divisible into parts": thus making the quantity to be the thing from which the notion arises, which some called the *res quanta*. This idiom is common in all times; and it has sometimes created confusion, and that in every line of thought, from agriculture to logic. We should perfectly well understand what a person meant who said that he had bought a hundredweight of sugar from Smith, and had sold *as much* to Jones, but not the *same quantity:* and we should also understand the charge of having made a blunder which might be brought against the speaker. But there is no blunder at all: the phrase has always been in use, and has lasted from the time of the schoolmen, of whom many defined *quantity* as being *res per se divisibilis in partes*. Blunder begins when a person confuses this old concrete sense with the modern one, in which *quantity* is the proper answer to *how much?* on a thing which admits of the notion of more and less.

Quantity admits another important division. In some quantities (now meaning *res quantæ*) we hold the parts in joint and separate existence at once, as in length, area, solidity, angle, time, number. In others we have not the separate perception of parts, though sensible of a whole which we are conscious might be more or less. Thus when we see a foot, we see the inches: but when we feel a pound, we do not feel the ounces. Some of the old writers say that it is essential to quantity to have *partes extra partes:* that is, to be of the first kind now under discussion. But they cannot help admitting quantities which do not satisfy this so-called essential condition. The truth seems to be that only in the fundamental notions of mathematics, space, time, and number, do we feel cognisant of the *separate* existence of parts in a whole by the same means which make us cognisant of the whole. In other things we learn by instruments, material or mental. We should never have divided *weight* into parts, if it had not been for the invention of the balance: nor *belief*, if it had not been for the calculus of probabilities, aided, in the first instance, by the definiteness of the cases which are on the cards or on the dice.

QUANTITY OF MATTER. [Mass.]

QUANTITY OF MOTION. [Momentum.]

QUARANTINE. Quarantine regulations are regulations chiefly of a restrictive nature, for the purpose of preventing the communication from one country to another of contagious diseases, by means of men, animals, goods, or letters. The origin of the term *quarantine* (which originally signified a period of forty days during which a person was subject to the regulations in question) is explained in the article Lazaretto. The period of forty days during which a widow entitled to dower can remain in her husband's mansion-house after his death is also called, in our law, the widow's quarantine. (Blackstone's 'Commentaries,' vol. ii.)

Quarantine regulations consist in the interruption of intercourse with the country in which a contagious disease is supposed to prevail, and in the employment of certain precautionary measures respecting men, animals, goods, and letters coming from or otherwise communicating with it. Men and animals are subjected to a probationary confinement, and goods and letters to a process of depuration, in order to ascertain that the contagious poison is not latent in the former; and to expel it, if it be present, in the latter. Quarantine regulations respecting *men* and *animals* are therefore founded on the assumption that the contagious poison, after having been taken into the constitution of a man or an animal, may remain dormant in it for a certain time, and that a seclusion of a certain duration is necessary, in order to allow the disease time to show itself, or to afford a certainty that the disease is not there. Quarantine regulations respecting *goods* and *letters* are founded on the assumption that the contagious poison may be contained in goods and letters, and transmitted from them so as to communicate the disease to men.

The country from which the introduction of a contagious disease is apprehended, may either be conterminous with the country which establishes the quarantine regulations, or may be divided from it by the sea. Accordingly quarantine lines may either be drawn round a coast, as is the case in France, Italy, and Greece, with respect to the Levant; or they may be drawn along a land frontier, as on the frontier between Austria and Servia and Wallachia.

The contagious diseases which quarantine regulations are intended to guard against are plague and yellow-fever, and latterly cholera. We are not aware whether small-pox has ever been made a subject of quarantine regulations; but this question is now of no practical moment, since vaccination has supplied a preventive of small-pox far more efficacious than any quarantine regulations could be.

The most important disease, with reference to quarantine regulations, is the *plague of the Levant;* and in practice, quarantine regulations are of little importance except with respect to the intercourse by land and sea with Turkey, Asia Minor, and Egypt, and some other of the Mohammedan countries bordering on the Mediterranean.

In the article PESTILENCE there is an explanation of the nature of the disease styled plague, which, although formerly prevalent over the whole of Europe, is now nearly confined to the Levant; and it is there stated that its symptoms, morbid changes, history, and mode of propagation, bear so close a resemblance to those of the malignant typhus of this country, that it is difficult to regard them otherwise than as different types of the same disease. It is also shown in the same article that the plague of the Levant appears to be generated by the same causes which generate typhus in this country, namely, filthy, crowded, and ill-ventilated dwellings, want of personal cleanliness, defective drainage, and insufficient or unwholesome food (Report of Dr. Arnott and Dr. Kay, in the Appendix to the 'Fourth Annual Report of the Poor-Law Commissioners,' p. 103), and that when the disease has been thus generated, it may, particularly under the influence of any of the causes which originally produced it, be communicated from one person to another. It appears likewise that its communication from one person to another is promoted not only by filth, want of ventilation, and the other usual accompaniments of squalid poverty, but also by certain atmospheric causes, such as a certain state of heat, moisture, &c., respecting which we are as yet imperfectly informed. The plague, therefore, is both epidemic and contagious; that is to say, it may either be generated by local causes, which simultaneously affect a large number of the inhabitants of a country, or it may be communicated directly from one person to another. Where a disease is both epidemic and contagious, it is difficult to determine what proportion of the cases of it are due to local causes and what proportion to contagion. The analogy of typhus in this country would lead us to believe that the number of cases of plague in the plague countries produced by contagion is small as compared with the number produced by local causes. The invisible nature of the ordinary causes of plague and other epidemic diseases, and the simultaneous seizure of many persons in the same district, the same street, or the same house, have naturally led to the belief that the disease is in every case communicated from one person to another; according to the fallacy ingeniously exposed by Dr. Radcliffe, who, on being asked his opinion respecting the contagiousness of epidemic diseases, answered: "If you and I are exposed to the rain, we shall both get wet; but it does not follow that we shall wet one another."

This view of the ordinary causes of plague is likewise confirmed by the undoubted fact which is adverted to in the article PESTILENCE, that the poor are the chief sufferers by it, and that it prevails most in the filthiest and worst quarters of towns. Dr. Patrick Russell, in writing of the plague at Aleppo in 1762, makes the following remarks:—"The villages appeared to suffer in a singular degree, owing perhaps to the structure of the huts and cottages, which are small, with few or no windows, and stand crowded together. In this they resemble the Keisarias within the city, which are inhabited by the lower class of people, and in which the contagion spreads also with great fury. The inhabitants of the city of the same class, but who live in districts where the houses are less connected, suffered more than the middling class possessing more airy habitations, but less than the Keisarias. The people of rank, or in higher offices, *notwithstanding the promiscuous crowds frequenting their palaces,* suffered least of all. Neither the governors of the city, the cadi, nor the nakeeb, and very few of the agas of superior rank, were themselves infected, though the plague had penetrated into most of their harems, and many of the pages and other attendants without doors were carried off by it. In these great harems, however, the contagion seldom spreads much; of perhaps about forty females, not more than four or five being infected. . . . Of all people, the Jews appear to have the strongest dread of the plague, a circumstance in one light rather fortunate, no place being more favourable to its propagation than the habitations of the lower class of that nation. The houses are small, or, if large, the different apartments are crowded with different families. Many of the houses are more than a story below the level of the street, in a condition half ruinous, dirty in the extreme, damp, and badly aired, from the nature of the situation: and the wretched inhabitants are clothed in rags. When one of them is taken ill, and known to have the plague, he is immediately abandoned to the care of an attendant, and the rest of the family seek refuge, if possible, at some distance. The families lodged in the other apartments, all not having it in their power to fly, are obliged to remain, but avoid approaching the chamber of the sick, and restrain their children from going into the court-yard. Thus pent up, they suffer all the inconveniences of the hot season in the midst of perpetual dread, till at length, what often happens, they also are attacked with the distemper. It was not without horror I descended into these dreary mansions." (Russell's 'Historical Journal of the Plague,' pp. 61-64.)

From the fact of the plague prevailing principally among the poor, and rarely attacking the rich, it may be inferred either that the plague is produced exclusively by the filth, crowding, and bad food to which the poor are subject; or that, if it be contagious, the contagion does not in general take effect upon the inhabitants of spacious and cleanly houses, who are clean in their persons, orderly in their habits, and have a sufficient supply of wholesome food. We see that diseases which appear to be contagious under nearly all circumstances prevail equally among the rich and poor, and that none of the physical advantages possessed by the rich afford any security against it. Thus, before the introduction of vaccination, small-pox was equally destructive to persons of all ranks in society; and the contagious diseases which attack children, as measles and hooping-cough, make no distinction between the children of the rich and the poor.

There seems to us to be no reasonable doubt that the plague is contagious—in other words, that it can be communicated directly from one person to another—provided there be circumstances favourable to its transmission. A quarantine for men may therefore be expedient for countries where the spread of the plague, supposing it to be introduced, is not improbable. The duration of this quarantine ought to depend upon the time during which the disease may be latent in a person who has taken it by contagion or otherwise.

Since the plague is a peculiarly malignant and destructive fever, and runs its course with a rapidity far greater than typhus, there seems a fair ground for concluding that its poison would not be long latent in the human body. The answers of the protomedico of Malta respecting the plague in Malta of 1813, state that "the periods at which the disease made its appearance in different individuals after communication were various. It was generally from the third to the sixth day; sometimes longer, even to the fourteenth day, but not later." (Dr. Maclean, 'On Epidemic and Pestilential Diseases,' vol. ii. p. 29.) M. Ségur Dupeyron, the secretary of the Council of Health in France, states, in his Report on Quarantine to the Minister of Commerce (May, 1834), that "the physicians who have made a close study of the plague are pretty generally of opinion that its poison cannot be latent in the human body more than fifteen days; and the cases of plague introduced into the lazarettoes confirm this opinion" (p. 48). We believe that the cases of plague which have in recent times occurred in the lazarettoes of Valletta, Marseille, and Leghorn have broken out either at sea or shortly after the ship's arrival. When the line of French steamers was first established, in 1837, between Marseille and the Levant, it was arranged that the steamers coming from the Levant should perform their quarantine at Marseille. But in consequence of several cases of plague having broken out on board the steamers before they could reach Marseille, the French government decided that they should perform their quarantine at the nearest practicable station, namely, Malta.

It is commonly assumed that actual or nearly actual contact is necessary in order to communicate the plague. "All measures against the plague (says M. de Ségur Dupeyron) are founded on the opinion that, except within a very small distance from the body, contact alone can give the disease. Consequently goods taken from ships with different bills of health are often placed in the same warehouse; and physicians who have visited plague patients, without having touched them, are not put in quarantine, and are permitted to go about immediately after their visit" (p. 76). We believe the idea that actual contact is necessary for the communication of the plague to be utterly erroneous; and we entertain no doubt that under circumstances favourable to its communication, such as filth, crowding, and want of ventilation, the poison of the plague might be introduced into the human body by inspiration through the lungs. We account for the escape of the physicians, guardians, and others, who come within a short distance of the plague-patients in lazarettoes, by the supposition that in the isolation, cleanliness, and good ventilation of a well-managed lazaretto, the contagion of the plague is exceedingly feeble.

With respect to the quarantine of animals, it may be remarked that, according to the belief commonly received in the Mediterranean, all living animals are capable of communicating the plague. Accordingly horses, asses, cattle, and sheep are placed in quarantine upon their importation. There is, we believe, an idea among the Franks resident in the plague countries, that the horse cannot communicate the poison of the plague, but that it is frequently communicated by other animals, especially by cats. (See Maclean, vol. i. p. 202) We suspect that there is no foundation for the notion that plague can be communicated by means of animals.

Goods carried in ships or by land are subject to quarantine, according as they belong to the class of susceptible or non-susceptible goods. Goods which are supposed to be capable of containing and transmitting the poison of the plague are called *susceptible.* Goods which are supposed to be incapable of containing and transmitting the poison of the plague are called *non-susceptible.* All animal substances, such as wool, silk, and leather, and many vegetable substances, such as cotton, linen, and paper, are deemed susceptible. On the other hand, wood, metals, and fruits are deemed non-susceptible. In Venice an intermediate class, subject to a half quarantine, is introduced between susceptible and non-susceptible goods (Ségur Dupeyron, p. 70); but this classification appears to be peculiar to the Austrian dominions. All susceptible goods are unladen in the lazaretto, and are there exposed to the air, in order to undergo a process of supposed depuration.

The grounds of the received distinction between susceptible and non-susceptible articles must, we conceive, be altogether fanciful, since we cannot discover any evidence that the plague has ever been communicated by merchandise. Whenever the plague has been introduced into the lazarettoes of the Mediterranean it has always been introduced by passengers or their clothes. (Ségur Dupeyron, pp. 45–48.) It may be added, that the persons employed in the process of depurating susceptible goods have never been known to catch the plague, which could scarcely have failed to be sometimes the case if the poison of the plague could be transmitted through goods. (See answer 28 of the Maltese protomedico, in Maclean, vol. ii. p. 31.) It seems to be likewise supposed that some substances are not only non-susceptible, but can even nullify the poison of the plague in susceptible articles. "At Trieste (says M. de Ségur Dupeyron) the juice of dried grapes is considered as a purifier; and consequently currants in susceptible wrappers are allowed to pass without the wrappers being subjected to any quarantine" (p. 72).

There appears, however, to be conclusive evidence that the clothes and bedding of plague patients have transmitted the plague. (Dupeyron, pp. 32-71.) We believe the danger of its transmission in this manner to be equal to the danger of its transmission by passengers.

We are not aware of any well-authenticated example of the transmission of plague by means of letters. Nevertheless as paper is considered susceptible, letters coming from and passing through the plague countries are opened and fumigated at the lazarettoes, a process which is often productive of mistakes, delays, and other inconveniences.

Every ship is furnished by the consul or other sanitary authority at the last port where it touched with an instrument, styled a bill of health, declaring the state of health in that country. If the ship brings a clean bill of health, the passengers and goods are not subject to any quarantine. If she brings a foul bill, they are subject to quarantines of different durations, according as the plague is known or only suspected to have existed in the country at the ship's departure. On account of the prevalence of plague in the countries upon the Levant, they are considered as permanently in a state of suspicion, and no ship sailing from any of them is considered to bring a clean bill. The periods of quarantine vary from two or three to forty days; the usual periods are from ten to twenty days.

For a description of the buildings in which passengers usually perform their quarantine, and in which goods are depurated, see Lazaretto. The most spacious and best appointed lazarettoes in the Mediterranean are those at Malta and Marseille. To the statements contained in the article just referred to, we add the following curious description of a quarantine station on a land frontier, quoted from a manuscript journal in Murray's 'Handbook for Southern Germany,' p. 457:—"Outside Orsova, by the waterside, and near the ferry over the Danube, stands the Parlatorium, a wooden shed in which the market (skela) is held three times a week. On account of the quarantine regulations, the inhabitants of Servia and Wallachia are prevented coming in contact with the subjects of Austria, and dare not cross the frontier without an escort. The Austrian quarantine is five days for those who come out of Wallachia, and ten for those from Servia, increased to forty days in time of plague. The Wallachians, again, have a quarantine of five days against the Servians; so that none of the three parties can intermix for the purpose of buying or selling, nor can they touch each other's goods. On this account, the building where the market is held is divided by three partitions, breast high, behind which the dealers of the three nations are congregated. In an open space in the centre is a table, by the side of which the Austrian quarantine officers take their stand, aided and supported by a guard of soldiers with fire-arms and fixed bayonets to enforce order and obedience. Whenever a bargain is made, the money to be paid is handed to one of the attendants, who receives it in a long ladle, transfers it to a basin of vinegar, and, after washing it, passes it on to the opposite side. The goods to be purchased are placed within sight, and are immersed in a tub of water, or fumigated, when they happen to change owners. It is an amusing sight to see the process of bargaining thus carried on by three parties at the distance of several yards from each other, attended by the vociferation and gesticulation inseparable from such business. When the bartering is transacted, the Wallachians are escorted back to their own territory, as they had previously been in coming to the spot, by a guard of soldiers, and the Servians recross the river in their boats."

The institution of quarantine originated at Venice, in which city the expediency of some precautions against the introduction of the plague was suggested by its extensive commercial relations with the Levant. A separate hospital for persons attacked by the plague was established in an island near Venice, in 1403; and the system of isolating passengers and depurating goods appears to have been introduced there about 1485. The system thus established in Venice gradually spread to the other Christian countries in the Mediterranean, and has been adopted, to a greater or less extent, over all the civilised world.

Attempts have been made to modify the quarantine laws without success.

The reason why it is necessary for a nation to adapt its quarantine regulations to the received opinions upon the subject, is explained in the following extract from a paper respecting quarantine regulations in the Mediterranean, which was printed in the Malta 'Government Gazette" of the 19th December, 1838:—"The quarantine regulations of the English colonies in the Mediterranean cannot be changed by the simple will of the English government without producing inconveniences far greater than those arising from the existing system. If the English government should change the quarantine regulations of Malta and its other colonies in the Mediterranean without previously obtaining the approbation of the sanitary authorities of the neighbouring countries, the pratique granted in those colonies would not be received elsewhere; and all vessels coming from any of those colonies would be subjected to a quarantine of observation (from eight to fifteen days). The latter liability would attach to ships of the royal navy as well as to merchant vessels; so that no ship of war sailing from Malta could communicate with any part of France, Italy, or Austria, without being previously subjected to a quarantine of observation. Malta, in particular, would suffer most severely by being unable to give an effectual pratique to ships performing quarantine in the harbour of Valletta, and by subjecting all ships clearing out of that harbour to a quarantine of observation. Not only would its transit trade be almost completely destroyed, but it would lose its importance as a quarantine station. Its importance as a quarantine station is now daily growing, on account of the establishment of the French steamers to the Levant, and the use of the overland journey to India. It would, however, cease to be a quarantine station if its pratique was not received by the Board of Health at Marseille, and by the other sanitary authorities of the Mediterranean. In order, therefore, that the quarantine regulations of the English colonies in the Mediterranean might be safely altered, it would be necessary that the alterations should be made in concert with the governments of the neighbouring European countries."

The small states of Italy have been suspected (and, we fear, with justice) of abusing quarantine regulations for the purpose of preventing commercial intercourse, and also for the sake of the profit to be made by farming out the quarantine dues.

The heads of the English law respecting quarantine are contained in the 6 Geo. IV. c. 78. This Act also confers upon the king in council extensive powers for making quarantine regulations. A full official abstract of the regulations established by this statute, and of the orders in council made under it, may be seen in M'Culloch's 'Commercial Dictionary,' article 'Quarantine.'

In 1850, upon the invitation of the French Republican Government, it was agreed among the different states which had coast possessions in, or close to, the Mediterranean, that an international conference on the subject of quarantine should be held in Paris. Delegates attended this meeting from France, Great Britain, Austria, Russia, Sardinia, Tuscany, the Papal States, Naples, Turkey, Greece, Spain, and Portugal. M. David, of France, was appointed president, and the congress sat from the 23rd of July, 1851, to the 19th of January, 1852. Although the resolutions come to by this body are important, they have only been very partially acted on up to this moment by the nations represented. At one of the earliest sittings of the congress it was decided that only two kinds or degrees of quarantine be henceforth recognised; namely, "quarantine of observation," and "quarantine of rigor or strictness," and that the third, or intermediate kind, "suspected quarantine" should be discontinued. Quarantine of observation involves only the enforced detention and isolation of a vessel with all persons and things on board for a specified time, due attention to ventilation and cleanliness being required to be observed. In strict quarantine, besides a longer detention, and a more rigorous isolation, other special precautionary measures, including the disembarkation of persons and the cargo in a lazaretto, and their presumed disinfection by fumigation, &c., are imposed.

At the same congress, it was resolved that the three diseases—plague, yellow-fever, and malignant cholera, should be held in an especial manner as demanding the use of quarantine measures for the protection of a country against their introduction from abroad.

The resolution with regard to cholera was not adopted without much opposition. Dr. Milroy, in his paper on the subject of the convention, reprinted in the transactions of the 'National Association for the Promotion of Social Science' for 1859, says, "The convention based upon, and embodying the results of their deliberations, has hitherto been adopted by only a few of the represented powers, namely, by France and Sardinia in the first instance, and at a later period by Portugal, Tuscany, and Turkey. This country, among others, has most wisely, I think, declined to follow the example; for there is certainly much in the proposed restrictions upon freedom of intercourse, on account of the apprehended risk of imported disease, that appears to me to be unnecessary, and therefore objectionable. And it is a fact not undeserving of notice, that in more than one of the countries which took part in the conference, the quarantine system pursued since 1851 seems to be now actually more vexatious and oppressive than it was before."

The National Association for the Promotion of Social Science appointed a quarantine committee in 1858, who issued a series of queries for transmission to governors of colonies and British consuls in foreign countries, on the subject of quarantine. Replies to these queries have been received from above two hundred different channels, and abstracts of these returns have been published by the Board of Trade. The first abstract, published May, 1860, consists of an "Abstract of the regulations in force in foreign countries respecting quarantine." The second paper consists of "Returns of information on the laws of quarantine," published August, 1860. These papers contain by far the largest amount of information to be obtained at present on the subject, and it is hoped that their publication will lead to permanent changes in the present laws of quarantine.

QUARE IMPEDIT. When an ecclesiastical benefice becomes vacant, unless the patron [ADVOWSON] present his clerk, that is, a clergyman, to the bishop of the diocese for institution, within six calendar months, the right lapses to the bishop, who may collate to the vacant benefice. But if a presentation be made by the patron within the six months, and that presentation is rendered ineffectual by the bishop's refusal to institute the clerk presented, the patron may obtain redress for this interference with his right of patronage in an action of Quare impedit, a proceeding so called because therein the defendant is required to state Quare impedit (why he hinders) the plaintiff from exercising his right of presentation. If the bishop be the sole disturber of the right, as is the case when he rejects the clerk upon an unfounded allegation of personal incapacity, as illiterature, immorality, &c., the action of Quare impedit is brought against the bishop alone. Where the bishop has instituted a clerk upon the presentation of a party wrongfully claiming to be patron, the action is usually brought against the bishop, the patron so claiming, and his clerk jointly; for unless the bishop be made a party to the suit, a title to present by lapse will accrue to him if the suit remain undetermined at the end of the six months, and the clerk instituted is shown to be an intruder. If the clerk be omitted, there can be no process (in a suit to which he is no party) to remove him from the benefice in case he has been instituted; and the consequence will be that the plaintiff must lose his right of presenting for the present turn.

The writ by which this action is now commenced is the same as in other suits (23 & 24 Vict. c. 126, s. 26). The plaintiff, in his declaration, sets out some former presentation to the same benefice, and if that presentation was not by himself, he must formally deduce a title to himself, by descent or purchase, from the party by whom the presentation on some former vacancy is alleged to have been made. The declaration must also show a disturbance before the bringing of the action. Upon this the bishop and the clerk may disclaim all title, save only, the one, as ordinary, to admit and institute, and the other, as presentee of the patron, who is left to defend his own right. But if the bishop has done more than he was bound to do as ordinary, especially where he has wrongfully collated the benefice, the plaintiff may, in his replication, allege special disturbance in the bishop for the purpose of making him a substantial defendant. If the right be found for the plaintiff on the trial, the jury who try the cause are to inquire of three other points: 1st, Whether the church, &c., is full, and if full, of whose presentation; for if it be of the defendant's presentation, then the clerk is removeable, provided the writ has been brought in due time; 2nd, What the value of the living is, and this with a view to the assessment of damages, which are directed to be given by the statute (13 Ed. I.); 3rd, In case of plenarty (that is, of the benefice being full), upon a usurpation, whether six calendar months have passed between the avoidance and the time of bringing the action; because the statute which permits a usurpation to be divested by a Quare impedit, does so only when the action is brought within the six months, and at common law plenarty is a bar to the action of Quare impedit, however early the action may have been commenced. If the jury find that the plaintiff had the right to present, and that his action was commenced within the six months, he has judgment to recover this presentation; and if the church, &c., be full by institution of any clerk, process issues to remove him, unless whilst the action was depending, the bishop (not having been made a party to the suit) has collated by lapse; in which case the plaintiff loses the present presentation, but is entitled to recover the full amount of the income of the benefice for two years from the defendant, the pseudo-patron, as a satisfaction for the turn lost by his disturbance; and in case of inability to pay, the defendant is liable to imprisonment for two years. But if at the termination of the suit the church still remains void, the party to whom the presentation is found to belong, whether plaintiff or defendant, may sue out a writ "ad admittendum clericum," by which the bishop is commanded to admit and institute the clerk of the successful party. If, upon this writ, the clerk be not admitted, the patron may recover satisfaction in damages against the bishop in an action for such refusal.

The patron only, and not the clerk, can maintain an action against the disturber. But under several statutes passed in the reigns of James I., William and Mary, and Anne, which took away the right of presentation from Roman Catholic patrons, the clerks presented are empowered to take certain proceedings in support of their interests. The right of presenting to benefices belonging to Roman Catholic patrons is vested by those statutes in the universities of Oxford and Cambridge, according to a distribution of counties given in the act of James I.; most of the counties in the south and west of England being for this purpose annexed to Oxford, and those in the north and east to Cambridge. The 12 Anne, st. ii. c. 14, provides (s. 4) that besides the writs of Quare impedit which the universities as patrons are entitled to bring, they or their clerks may file a bill in equity against any person presenting to such livings and disturbing their right of patronage, in order to compel a discovery of any secret trusts for the benefit of Roman Catholics in evasion of these statutes: and also (by 11 Geo. II. c. 17) to compel a discovery whether grants or conveyances of such advowsons were made *bonâ fide* to a Protestant purchaser for the benefit of Protestants and for a full consideration; without which requisites every such grant and conveyance of any advowson is declared to be void. This is the only case in which the clerk is at liberty to interfere with the recovery of a presentation of which he is afterwards to have the advantage.

The statutes giving to the universities the right to present to benefices belonging to Roman Catholic patrons do not affect the exercise of the right of patronage in any other class. Dissenters, and even Jews and pagans, may exercise this right. When the disability was first created, persons professing the Roman Catholic religion were the only class from whom any danger in a political or religious point of view was apprehended; and the circumstance that persons who have been admitted to holy orders in the Church of Rome are capable of holding benefices in the Church of England may perhaps have increased the jealousy with which Roman Catholic patrons were regarded by the legislature.

It has lately been held that these statutes do not transfer any right of presentation to the universities where the patronage of a vacant benefice is vested in several parties, unless all of them be persons professing the Roman Catholic religion. If there be two patrons, one a Protestant and the other a Roman Catholic, the entire right of presentation vests in the former.

Finally, no person shall bring a Quare impedit or any suit to enforce a right to present to or bestow any ecclesiastical benefice after the expiration of the period during which three clerks in succession shall have held the same, all of whom shall have obtained possession thereof adversely to the right of such person, or of some person through whom he claims, if the times of such incumbencies taken together shall amount to the full period of sixty years; and if the time of such incumbencies shall not together amount to the full period of sixty years, then after the expiration of such further time as with the times of such incumbencies will make up the full period of sixty years. (3 & 4 Will. IV. c. 27, s. 30.)

QUARRY and QUARRYING. A quarry is an excavation in the ground, from whence are extracted marble, stone, or chalk, for the purposes chiefly of sculpture, building, and civil engineering. The name appears to have been applied to such excavations from the circumstance that the materials obtained from them are there quadrated or formed into rectangular blocks.

Egypt abounds with rocks of calcareous stone, sandstone, and granite; and all these materials have been employed in the formation of the massive works which yet remain to attest the magnificence of the ancient people of that country. The walls of most of the temples were constructed of sandstone, which appears to have been chiefly obtained from the quarries stretching along the banks of the Nile, in the mountains of Silsileh; but the obelisks and statues which adorned those temples are formed of Syenite, or Oriental granite, drawn from the quarries in the islands of Philœ and Elephantine, and particularly from the vast excavations in the mountain terraces about Syene. ('Egypt. Antiq.' 'Library of Entertaining Knowledge.') The stone which has served for the pyramid of Cheops is a carbonate of lime, of a light gray colour; and the same kind of stone forms the interior mass of the pyramid of Mycerinus; but the latter is covered with red granite. The monolith at Sais, in the Delta, was formed of a single block of granite, which was floated down the Nile on a raft, from the quarry in Elephantine. (Herod. ii. 175.)

The master-pieces of Grecian sculpture were executed in the rich white marbles of Attica and the islands of the Archipelago. The quarries of Mount Pentelicus near Athens supplied the materials for the Parthenon and the temple of Theseus in that city, and for the temple of Ceres and Proserpine at Eleusis; and both in Greece and Asia Minor an abundance of stone of a greenish-white was dug from the earth for the ordinary purposes of architecture. The marble of Pentelicus, which lies on the surface of the rocky mountain, was obtained by cutting the side of the hill into vertical cliffs; and about the foot of the escarpment there still remain some of the blocks of marble partly cut in form for the shafts of columns. The quarries at Ephesus are said to have constituted an immense labyrinth. The quarry in the hill Epipolæ, with the stone from which the edifices of Syracuse were constructed, appears to have been of vast extent, since it was capacious enough to contain the 7000 Greek soldiers who had been taken prisoners when the army of Nicias retreated from that city. (Thucyd. vii. 86.) The quarries of the Greeks and Romans were worked by slaves; and as the labour was of a severe kind, we find frequent allusions to the practice of sending unruly slaves to work in the quarries as a punishment.

We learn from Vitruvius (lib. ii. cap. 7) that the buildings of ancient Italy were constructed with stones of several different kinds. The Tiburtine or Travertine stone is a calcareous rock; it was employed in constructing most of the buildings of ancient Rome. The quarries in Umbria and Picenum furnished a white stone which could be cut with a saw, and would stand well in situations where it was sheltered from the weather, but was liable to be destroyed by rain or frost. On the other hand, the red stone obtained from the quarries about the Vulsinian Lake (*Bolsena*), on the borders of Tarquinii, would stand both frost and fire, and would last for ages: on which account it was generally employed for sculptured works. After the destruction of Rome by fire, in the time of Nero, the houses are said to have been rebuilt of the Alban and Gabian stone, which has the property of resisting the action of that element. The quarries of Carrara, on the north-western slope of the Apennines, have long been celebrated for the fine white marble which is so much employed in the north of Europe for statuary.

The British Isles abound with stone of nearly every different kind that can be employed with advantage in architecture. The quarries of Aberdeenshire supply large quantities of the best granite, which is employed for bridges, river walls, and every work where strength and durability are most required. The Peterhead granite from the same county takes a beautiful polish, and is frequently employed for columns, chimney-pieces, and other ornamental works. The Grampian Hills in Scotland, the quarries in the county of Dublin, and those of Newry in the county of Down, in Ireland, also produce several varieties of the like material. In England granite is obtained chiefly, and in great abundance, from the quarries in Cornwall, where that material is usually designated moor-stone.

Sandstone, both red and white, is obtained in large quantities for the purposes of building, from Yorkshire, Lancashire, and Derbyshire; and the principal edifices in Shrewsbury have been constructed chiefly of the white kind which is furnished by the quarries near Grinshill in Shropshire. A millstone-grit, now much used in England, is supplied from Bramley and Hedon in Yorkshire. The red sandstone is dug from the quarries at Barra, Tranent, and other places in Lothian; from those at Kingudie in Perthshire, and also from Arbroath in Forfarshire. In Ireland it is obtained from the quarries in Tipperary, and the county of Cork.

SLATE QUARRIES are noticed in a separate article.

The stone most extensively diffused over England and Ireland is that which is denominated limestone, and which, from the facility it affords for working it, is most generally called freestone. It is quarried to some extent in Gloucestershire, Shropshire, Derbyshire, and Oxfordshire, and a gray species is obtained in Yorkshire and Northamptonshire; but the principal quarries of this material are in Dorsetshire and in the country about Bath. Those in Dorsetshire are situated about Kingston in the Isle of Portland, and at Swanwich, or Swanage, in the Isle of Purbeck. The most extensive quarries about Bath are at Combe Down, where the ground has been undermined for several miles. More than 30,000 tons of Portland stone are said to be exported annually to London, where it has been very generally employed from the time that Inigo Jones used it in the construction of the Banqueting-house at Whitehall. It was also extensively used by Sir Christopher Wren in the building of St. Paul's cathedral, the Monument, and most of the public edifices in the city after the great fire which occurred in 1666. It is, however, not so much used at present as formerly. The stone obtained from Purbeck is of various kinds; some of it, which is capable of taking a good polish, has been used for the pillars of Salisbury and Canterbury cathedrals. It is of a darker colour than Portland stone, and in general it is not so good; the blocks raised from the quarries are also smaller. The material is frequently used as a flag-stone for the steps of buildings and for paving the streets. The hills containing the stone lie in a direction nearly east and west; the beds have a considerable dip or inclination to the horizon, and being covered by a large mass of earth, the men work in quarries under ground. The stone of Portland and Purbeck constitutes the upper oolite formation of the geologists; and in the former district the quarries are cut through several different beds. The first, or that immediately below the vegetable earth, consists of a cream-coloured limestone, three or four feet deep; and next to it is the *cap-stone*, which is of the same colour, very hard, and about ten feet thick. Below these is a species of rock composed of fragments of oystershells cemented together; and still lower is a bed, five feet thick, of good white stone. This is followed by a quantity of flint about six feet deep, a second bed of good stone five feet deep, and a thin layer of stones of small value. The best building-stone lies still deeper, and the beds of it vary in thickness from seven to fourteen feet. Underneath all these are masses of flints, extending to the depth of fifty or sixty feet.

The quarries near Bath furnish the stone which bears the name of that town, and which occurs generally in three beds, of variable thicknesses and different qualities. That in the middle is far superior to those which are above and below it. The depth of the middle bed is in some places as much as 30 feet; the stone when first taken from the quarry is soft, but it becomes hard after having been for a time exposed to the air. The depth of the upper bed varies from 20 to above 50 feet, and the material is either shelly or argillaceous; that of the former kind appears to have been employed by the Romans for the edifices they constructed in this part of the country, and is very durable.

The marble and limestone quarries which were opened near Plymouth in 1812 furnished the material used in the formation of the breakwater at that place; the stone was raised from thence in blocks weighing from one to above five tons. The material selected for the construction of the Houses of Parliament is a magnesian limestone, which abounds in all the tract of country from Durham to Northampton; and that which is actually employed is obtained from several different quarries, principally those near Norfall and Anston in Yorkshire, and near Bolsover in Derbyshire. The unfortunate result of this selection will be found noticed under STONE FOR BUILDING.

Limestone is found in Scotland, where it is occasionally employed for architectural purposes. It is also plentiful in many parts of Ireland; and quarries of this material, of a rich kind, have been opened in Queen's county, and in the counties of Dublin, Meath, and Cork. The limestone district of Kilkenny is famous for its quarries of black marble so much used for ornamental purposes; and good flagstones for paving are obtained at Shawhill in the same county.

The quarries in the Cotswold Hills in Gloucestershire afford in abundance a blue claystone for building; and the best stones for pavements are obtained from those at Ealand, or Eland, near Halifax in Yorkshire. The quarries near Maidstone, on the south bank of the Medway, produce much of what is called ragstone, a material which is occasionally used in Kent for building, but chiefly in the construction of sea-walls and for paving the roads. Lastly, about Reigate and Godstone in Surrey is found a soft stone which has the property of withstanding the action of fire, and which on that account is much used for chimneys, ovens, and furnaces; but it is scarcely fit for any other purpose.

A valuable table of the principal quarries of sandstone and limestone in England accompanies the 'Report concerning the Qualities of Stone with reference to the New Houses of Parliament' (1839).

Having thus explained the nature of *quarries*, we proceed to notice *quarrying*, which is the operation of extracting from the ground, or detaching from the sides of rocks, marble, stone, or other minerals, in considerable masses; generally also this operation is accompanied by a reduction of the masses to rectangular forms.

When the material to be excavated lies vertically below the surface of the ground, the work commences by removing the earth to a depth sufficient to lay that material bare, in order that it may be separated into blocks, and removed; but when the stone, &c., is in the interior, and near the side of a mountain or hill, the workmen proceed as in the operation of mining, running galleries into the ground, and leaving pillars of the material for the support of the mass above them.

A quarry of small extent is opened by sinking vertically in the ground a shaft, into which the men descend by ladders; and the blocks of stone, being separated from the mass, are drawn up by means of cranes, which are worked by a windlass or other machine. In working the larger quarries, the vegetable mould forming the upper surface is removed by the spade; and the beds immediately underneath, generally consisting of rag, or stone of an inferior quality, are broken up by gunpowder or otherwise, and conveyed to a distance. The stones intended for sale, and which are generally in beds much below the surface, are sometimes also detached from the mass by blasting [MINING]; but as by this process the blocks are broken irregularly and the stone wasted, a different method is generally employed. The large mass of stone, as it exists in the quarry, consists of strata contiguous one to another, and the surfaces in contact form planes of *cleavage*; in lines parallel to which the stones being more easily divided than in any other direction, these lines constitute what is called the *cleaving* grain of the material. In order, therefore, to separate a large block from the mass, a series of iron wedges, placed in line a few inches asunder, on the natural face of the rock and in the direction of the cleaving grain, are driven into the stone till a part is loosened: a channel is then cut in the direction of the length of the intended block, and at a distance from the natural edge of the stone equal to its required breadth; and wedges being planted in the channel, they are driven by repeated strokes till the stone is split in that direction also. In the hardest stones, the wedges are placed not in the channels, but in what are called *pool* holes sunk in the direction in which the block is to be severed from the mass. A similar operation is then performed in the direction of the breadth of the block; and thus a large portion is detached from the original mass.

The natural strata of the stone in different quarries are in different positions; frequently they are horizontal, but generally they are inclined to that plane, and sometimes they are vertical: occasionally also both the first and last of these positions are assumed by the stone in the same quarry. It is evident that the separation of the blocks from a mass must be most easily effected when the natural strata are in vertical positions.

After the blocks have been severed from the mass, they are reduced as nearly as possible to a rectangular form; and this is done by means of a tool called a *kevel*, pointed at one end and flat at the other, with which the irregular parts are knocked off. The blocks are then usually, by means of cranes which are capable of being moved from place to place, raised upon trucks or low carriages; and these are drawn, generally on iron railways, to the quays or wharfs where the stone is put on ship-board. A curious account is given by Vitruvius of an unsuccessful attempt which was made by an engineer named Paconius to bring from a quarry a mass of stone containing about 576 cubic feet. For this purpose, two broad cylinders of wood, 15 feet in diameter, were constructed; and the stone, being raised from the ground, was made to rest between them, the line of its length being in a horizontal position in the direction of their common axis, then a rope being wound round the circumference of the united cylinders in the middle of the length of the latter, and one end of it being made fast to the harness of the oxen, it was intended that, by the motion of the animals, the cylinder should revolve on the ground, and the stone be brought up to its place. The contrivance appears to have failed; but had the oxen been attached to the two ends of the cylinder instead of its middle, there is no reason to doubt that it would have succeeded.

So far as concerns our own country, granite is the hardest stone quarried in any considerable quantity. The largest operation in Cornish granite is believed to have been the detaching and working of a block weighing 33 tons, for an obelisk. The granite of Brown Willy, sent down to Wadebridge for shipment; that of the Cheesewring, shipped at Liskeard; that of the Par Valley, shipped at Par Harbour; and that of Penrhyn, shipped at Falmouth,—are well-known examples of Cornish granite. In some of these quarries the stone is of beautiful texture, and glistens brightly in the sun; so hard is the stone, that the blows of the picks against it give forth a real musical sound, varying in pitch according to the size of the pick. We have said that the use of gunpowder is rather limited in quarries of stone for building, because the substance is apt to be too much shattered by this explosive force. We may, however, refer to Blasting for further information as to this process—especially in those instances where an electric current is employed to ignite the powder. Enormous masses of Holyhead mountain are now being quarried in this way, to furnish materials for a new breakwater in the harbour of refuge; a railway extends from the place of detachment to the place of deposition, thereby greatly facilitating the operations.

At the Aberdeen meeting of the British Association, in 1859, Mr. Gibb gave an account of the Aberdeenshire granite quarries, from which it appears that those quarries have been worked about two centuries and a half. The operations were on a small scale until about the year 1741, when an extensive fire at Aberdeen led to a municipal order that the fronts of houses should be built of stone, instead of wood as heretofore. Aberdeen granite was first used in the London streets in 1764; but Waterloo Bridge was the first great metropolitan work constructed in this stone. The quarries are about twenty in number, and present five kinds of granite, technically known as blue, red or Peterhead, light red, soft gray, and white. It exhibits irregular masses, and a columnar structure. A good deal of blasting is necessary in the operations. The best stone is now found at some depth beneath the surface. Dressing machines have occasionally been tried to bring the blocks of granite into form, but they have not been satisfactory, because they acted like a plane; whereas granite requires a kind of percussive action to bring down the surface. There are about 500 workmen and 50 horses at the quarries. The produce is now about 50,000 tons annually, of which 30,000 tons are exported.

It is right to observe that builders generally consider it advantageous to dispose the stones in the lower part of an edifice in the same position as they had when lying in the quarry; it being understood that they are then best capable of supporting the weight of the superstructure.

QUART, the same word as quarter, but always used (in our language) for the quarter of a gallon. [Gallon.]

QUARTER, the fourth part of anything. The frequency of division into four parts has caused the word to be used sometimes in the sense of a part or portion allotted. Thus the portion of a camp or barrack allotted to one soldier is called his *quarters*.

QUARTER. [Heraldry.]

QUARTER-SESSIONS. [Sessions.]

QUARTER-SQUARES. A table of the fourth part of the squares of numbers may be substituted for one of logarithms in multiplication. For since

$$\frac{(a+b)^2}{4} - \frac{(a-b)^2}{4} = ab,$$

a table which gives the squares of the halves of numbers will, by the addition of the squares of the halves or quarter-squares, give the product. Where $a+b$ and $a-b$ are odd, the fraction $\frac{1}{4}$ is omitted from both squares, which obviously produces no effect. Thus the *tabular* quarter square of 5 is not $6\frac{1}{4}$, but 6. [Table.]

QUARTILE, a term of astrology and ancient astronomy. Two bodies are said to have a quartile aspect when their longitudes differ by 90 degrees, or one quarter of the whole great circle.

QUARTZ. [Silicon.]

QUASSIA. The wood of two different trees is known in commerce by this name: one, formerly very common, but now extremely rare, is obtained from the *Quassia amara* (Linn., f. supp. 235, and Woodv., t. 77), a native of Surinam, Guayana, &c.; the other, *Picræna excelsa*, Lindley (*Quassia excelsa*, Swartz), is a native of Jamaica. Both kinds are imported in billets, sometimes a foot in diameter and several feet long; but before being used for medicinal purposes, they are cut into chips, which are of a light gray colour, or, by long exposure to the air, of a yellow or brownish hue. The physical characters of the two sorts are so similar, that it is difficult to distinguish them; but a watery infusion of the Surinam quassia by permuriate of iron is only rendered turbid, with grayish flocculent pieces floating in it, while that of the Jamaica quassia is rendered black by the same re-agent. Both are devoid of odour, but possess an intensely bitter taste, which is stronger but more disagreeable in the Jamaica quassia. This property at once distinguishes quassia from any other wood which may be substituted for it. The active principle seems to be *quassite*, a neutral body, which crystallises in white prisms, and is readily soluble in alcohol. Quassia has a poisonous influence over many of the lower animals, and perhaps even over very susceptible individuals of a higher grade. The infusion of quassia should be made with cold water. The *bitter cup*, now popular, is made of quassia, and is a convenient form of obtaining an infusion.

Quassia is regarded as a pure and simple bitter, possessing tonic properties of a very marked kind; and hence it is useful in many forms of debility, particularly of the stomach and muscular system. It is generally given in the form of infusion, which serves as a convenient vehicle for some of the preparations of iron, especially the protosulphate and the phosphate. The Jamaica quassia ought not to be employed as a vehicle for the permuriate of iron, as an inky fluid, instead of a clear transparent one, is the result. The want of aroma may be obviated by adding to the infusion a portion of the compound tincture of quassia ('Pharm. Edin.'), which renders it more grateful and more beneficial.

Infusion of quassia, sweetened with sugar, is useful to destroy flies, and is much safer than the fly-waters made of king's yellow or orpiment, a poisonous compound of arsenic; for should children or others drink the infusion, improved appetite would be the only result, whereas death is the frequent consequence of drinking the arsenical fly-water.

QUASSIN, or *Quassite* ($C_{20}H_{12}O_6$?). The bitter principle of quassia wood. [Quassia amara, in Nat. Hist. Div.] It may be obtained by treating the solid aqueous extract with alcohol, evaporating, and recrystallising. It forms small, white, opaque prisms, inodorous and very bitter. Nitric acid converts it into oxalic acid.

QUEEN, from the Saxon cþen, used to denote *mulier*, *femina*, *conjux*, as well as the most distinguished of women and wives, to whom now it is only appropriated. The other use of it, as betokening a sovereign princess who has succeeded to the kingly power, is an application of it not originally contemplated.

The king's consort has been regarded in all countries as a person of eminent dignity, and has been invested with privileges not allowed to any other married woman. In England she can purchase lands, and take grants from the king her husband; she has separate courts and officers, including an attorney- and a solicitor-general; she may sue and be sued apart from her husband, have separate goods, and dispose of them by will. She pays no toll, is not subject to amercement, and has a share in fines made to the king for certain privileges, which last is called queen's gold. Anciently manors belonging to the crown were assigned to her in dower, but this provision is now made by a Parliamentary grant. Again, there is thrown over her person a peculiar protection. It is as much treason to compass or imagine the death of the king's consort as of the king himself. To violate or defile her person is also treason, though she be consenting. It has been the usual practice to crown the queen with the same kind of solemnities as at the coronation of a king. In the case of Caroline, the consort of King George IV., who was living at the time apart from her husband, this was not done; but her right was asserted at the time by Mr. Brougham before the Privy Council.

The chief distinction between a queen-dowager and the widow of any other person of eminent rank lies in this, that though she marry with a commoner, she does not lose her rank; but no one can marry a queen-dowager without the special licence of the sovereign.

A queen-regnant, or princess who has inherited the sovereign power, differs in no respect from a king as to the political rights vested in the dignity.

QUEEN-CONSORT. [Queen.]

QUEEN'S METAL is a white alloy, used for making spoons, knife-handles, teapots, &c. It is intermediate in properties between Pewter and Britannia-Metal, and consists of 9 parts of tin, 1 of antimony, 1 of bismuth, and 1 of lead.

QUERCETIC ACID. [Quercitrin.]

QUERCETIN. [Quercitrin.]

QUERCIN. A crystalline matter said to be contained in oak-bark.

QUERCITANNIC ACID. [Tannic Acids.]

QUERCITE ($C_{12}H_{12}O_{12}$). A variety of sugar contained in acorns. It separates out in transparent prismatic crystals from a concentrated and fermented infusion of acorns; the tannin having first been separated by the addition of lime. It is soluble in water and in proof spirit, is not fermentescible, and does not reduce alkaline tartrate of copper. [Mannite.]

QUERCITRIC ACID. [Quercitrin.]

QUERCITRIN. *Quercitric Acid* ($C_{36}H_{18}O_{20}+2$ Aq.). The yellow colouring matter contained in quercitron bark. [Quercus, *tinctoria*, in Nat. Hist. Div.] An alcoholic tincture of the coarsely comminuted bark is treated with gelatin to remove tannic acid; on evaporation quercitrin crystallises out. It is an inodorous, bitter, crystalline powder, slightly soluble in boiling water, absolute alcohol, or ether, readily so in hot acetic acid, and very soluble in solutions of soda or ammonia.

Quercitrin is a glucoside; that is, by the action of dilute acids it breaks up into grape sugar (glucose), and a new body to which the name *quercetin* has been given.

Quercetin ($C_{24}H_8O_{10}$) is a citron-yellow granular powder, inodorous and tasteless. It is insoluble in cold water, only slightly soluble in hot water, but very soluble in alcohol or in alkaline solutions. Like quercitrin it is coloured green by perchloride of iron. Hlasiwetz has recently found that quercetin itself contains the elements of a sugar identical with phloroglucin, associated with a crystalline acid to which he gives the name *quercetic acid* ($C_{34}H_{12}O_6 + 7HO$).

QUERCITRON. The barks of *Quercus tinctoria*, the quercitron or black oak, and of the *Q. alba*, or white oak, of North America, are officinal in the United States, and that of the *Q. tinctoria* in the German pharmacopœia, but not the British. In the former they are employed from convenience, as being indigenous, though confessedly inferior in tannin and astringency to the *Q. Robur* (*pedunculata*) of Europe. The German pharmacopœias give quercitron a place because it furnishes a useful reagent for the salts of iron; its infusion yields no precipitate with gelatine. But its employment in dyeing, and also in dressing leather, is the chief cause of its being imported into Europe. There is one inconvenience in using leather tanned with it, namely, it imparts a yellow colour to the stockings of the wearer. This can be avoided by subjecting the leather to a particular but expensive process.

The same remedial powers, though in less degree, are possessed by quercitron bark as by that of the common oak-bark. It enjoys, justly or unjustly, the same reputation in America, as a preventive or cure of consumption; so persons threatened with consumption resort to bark-mills and tan-works. For medical purposes an infusion with *cold* water is best.

QUERCUS PEDUNCULATA (Willd.) The bark of this species, the true British oak, is used in medicine. Its appearance varies with the age of the bark, as well as of the tree from which it is obtained. Its excellence is determined by the period of the year when the tree has been barked. The best is obtained from coppice oaks, not from old or full-grown trees, and is better from the branches than the trunk. According to Sir H. Davy, the greatest quantity of tannin exists in the bark in spring, at the time when the buds begin to open ('Agricul. Chemistry,' 4th ed., p. 87), which is confirmed by Biggins. This is the period usually selected to decorticate the trees, owing to the greater ease with which it is then effected, the cambium which exists between the bark and wood allowing of their easier separation. The interior cortical layers are much richer in the active principles than the external ones.

Oak-bark is commonly met with in pieces from one to two feet long. That from young stems or branches is generally thin, tolerably smooth, having a silvery or ash-gray cuticle, and frequently clothed with lichens, chiefly of the genus *Verrucaria* or *Opegrapha*. When newly detached it is whitish internally, but by exposure to the air it deepens into brown, and becomes fibrous and cracked. The bark of old stems is much thicker, very rough and cracked, and greatly inferior in quality. The chief chemical constituents are: tannin (impure tannic acid), tannates of lime, magnesia, potash, &c., gallic acid, uncrystallisable sugar, pectin, and lignin. It has the peculiar and well-known odour of tan, and a bitter astringent, but afterwards sweetish, mucilaginous taste.

Oak-bark possesses all the properties of astringent substances, except the power of decomposing tartar-emetic. [Astringents; Antimony.] It is more employed externally than internally as a wash or injection. By long-continued application it can almost tan the living tissue, and either strengthen a weak part of the skin, or convert a secreting into a non-secreting surface, as in cases of prolapsed or inverted uterus. One of the most valuable applications, and at the same time cheapest, to surfaces threatened with gangrene from pressure, as in fevers, or old bedridden persons, is a wash formed by digesting oak-bark in weak distilled vinegar, and, after straining, adding hydrochloride of ammonia. It is not only unnecessary, but injurious, to make a decoction of oak-bark: no tanner would think of boiling his oak-bark before steeping his hides in it.

Powdered oak-bark with chamomile flowers is a cheap and often effectual mode of checking the paroxysms of agues.

(Cullen's *Mat. Med.*; Pereira's *Mat. Med.*)

QUERCUS INFECTORIA. [Galls.]

QUEVENNE'S IRON. [Metals.]

QUI TAM. In those statutes by which certain acts are prohibited under a penalty, it is usual to encourage the enforcing of the penalty by appointing the whole or some part of it to be paid to the person who shall take the risk and trouble, and incur the odium, of bringing the matter before a court of law. Where the part, commonly a moiety, is given to the king, the informer suing for the penalty proceeds in this form: "A. B., who, as well (*qui tam*) for our lady the queen as for himself, in this behalf prosecutes, complains," &c.

When a *qui tam* or other penal action is commenced, no other person can afterwards sue the defendant in respect of the same offence, whatever the result of the first action may be. It is therefore not unusual for offenders against penal statutes to seek to protect themselves by procuring one of their friends to sue. This, however, will be of no avail against a subsequent informer suing *bonâ fide*, provided the fraud and collusion in getting up the first action can be shown.

QUIA EMPTORES. [Feudal System.]

QUICK HEDGES. [Hedges.]

QUICKLIME. [Calcium.]

QUICKSANDS are those masses of loose or moving sand which are formed on many sea-coasts and generally at the mouths of rivers: those of the Nile and Senegal are among the most remarkable for these accumulations. The sands are generally conveyed by the rivers from the interior of the country, and being at first arrested by the waters of the ocean, they become, in many instances, by the action of the winds and tides, moveable *bars*, which are very dangerous to shipping. The loose sands on the coasts are, when dry, driven by winds over the land, which they then cover often to a considerable depth, overlaying the fertile ground and occasionally entombing whole villages: the coasts of Cornwall and Norfolk in England, and of Jutland in Denmark, are particularly subject to these encroachments [Dunes]; and it is stated that in the latter country there are vast beds of sand so loose as to be incapable of supporting the weight of a man. In Greenland there is a chain of ice-hills between two promontories of moving sand, which is driven by the winds far out to sea.

The easterly movement which gives the character of quicksands to the arenaceous deposits in and around the mouths of the Nile, takes place at all depths, and is extended to the shore itself. It is caused by the westerly gales and prevailing north-west breezes, which have also produced a range of sand-dunes extending from Cape Boulos at the most northerly point of Lake Boulos, eastward of the Rosetta branch of the river, to the mouth of the Damietta branch. These winds are both the accumulating and moving causes of this "stream of sand-dunes," as it has been termed. As fast as the wind removes the sun-dried sand from the beach, the surf re-accumulates it again, during every gale. The quicksands, therefore, are littoral as well as marine phenomena. There is a constant movement of the sand in the depths, both along the shore, and within the shore (which here merely separates the waters of the sea from those of the Delta), commencing from the Rosetta mouth on the east, and extending to the Damietta mouth on the west. It is also blown along the coast in a succession of dunes by one wind, or in part back again into the sea by another, less prevalent, but more violent wind. The subject is importantly connected with that of one of the most remarkable projected enterprises of the present age, the "canalisation" of the Isthmus of Suez, in order to effect a navigable communication between the Mediterranean and the Red Sea. The subject has been treated by one of our most eminent marine-surveying officers, Capt. Thomas A. B. Spratt, R.N., F.R.S., in 'An Investigation of the Effect of the prevailing Wave influence on the Nile's Deposits, and upon the Littoral of its Delta,' dated Alexandria, July 9, 1858, printed with four lithographs of maps and sections, by the British Admiralty in the following year; and from which copious extracts have been made public in a parliamentary return of 1860. The preceding notice of the Niletic deposits has been derived from the original paper. Capt. Spratt's actual investigation was of the most practical nature, by the observation of the winds and sea-currents, the examination of the coast, that of the sea-bottom by dredging, and the mineralogical and chemical examination of the deposits. The result, broadly, is this, that the Mediterranean entrance to the proposed canal would be perpetually filled up by the moving sands of the Nile drifted by the sea along the coast, and that, in the attempt to construct and maintain it, millions of money would be fruitlessly lost in the depths of the sea.

The sand of Bagshot Heath, which rests on the London clay, is in many places, at a few feet below the surface, saturated with water so as to constitute a perfect quicksand: and, on the borders of Oman, in Arabia, there was discovered by Baron von Wrede a remarkable quicksand, which is said to be more than 60 feet deep.

QUICKSILVER. [Mercury.]

QUIETISM is the name of the doctrine of certain ascetic Christians, who taught that the chief duty of man was to be wrapped up in the continual contemplation and love of God, so as to become totally independent of outward circumstances and of the influence of the senses, and they contended that when a man arrived at this state of perfection, the soul had no further occasion for prayer and other external devotional practices. Quietism is, in fact, the extreme of asceticism and of contemplative devotion. There have been men so disposed in all ages of Christianity, without forming a sect, and even the Mohammedans and Brahmins have their quietists; but it was a Spanish priest called Michael Molinos, in the 17th century, who first embodied the principles of quietism in his works, which were condemned at Rome, where the author was imprisoned and died in 1696. About the same time Madame Guyon, or Guion, in France, showed herself a great advocate of quietism. She was supported by Fenelon, and opposed by Bossuet. [Guyon and Fenelon, in Biog. Div.]

QUINA, or QUINIA,—one of the alkaloids of cinchona—*Medical properties of.* The mode of procuring this and other alkaloids from bark, and the mode of forming some of the numerous salts and combinations of these bodies, are already given under Cinchona, Alkaloids of. Soon after their discovery they were employed in the treatment of disease, and possessed some advantages over the crude bark, the insolubility of the woody fibre of which seriously distressed the stomach. A brief notice of these can only be given here; for fuller details reference may be made to Pereira's 'Mat. Med.;' Royle's 'Mat. Med.;' but the fullest exists in Dierbach, 'Die Neuesten Entdeckungen in der Mat. Med.,' vols. i. and ii. Pure quinia is too insoluble to admit of use. Some of its salts or solutions are used. Cinchonia is more soluble, but it also is only given in solution or combination. These may be classed under the acids, inorganic and organic, and the menstrua or solvents employed to facilitate their administration, augment their power, or render them more grateful to the patient. Of all, the most common is the sulphate of quinia. This is found in two states—the strictly neutral, formerly called disulphate, and the bisulphate. The superior solubility of the former entitles it to preference. Disulphate of cinchonine, and disulphate of quinidina (both termed sulphate of cinchonia, and sulphate of quinidina, though there are also bisulphates of these alkaloids) have the advantage of greater cheapness, and probably equal efficacy. A combination of an inorganic acid and an organic, in the form of a sulpho-tartrate of quinia, in syrup, has been used, but probably it has scarcely any advantage but from its greater palatableness, a merit found in a saccharated solution of bark, or combining extract of bark with confection of orange-peel, which renders it acceptable to children. Similar properties to this last combination are found in the officinal compound tincture of quinia. Amorphous quinine, as it is found in quinoidine, along with several other bases, is a most valuable form, and has the great advantage of comparative cheapness, a circumstance which fits it well for camp and hospital practice, since its efficacy as an anti-periodic is unquestionable. In one of the forms of elephantiasis, which is of a febrile character, and of malarious origin, and markedly periodic in its nature, the utility of quinine is most striking; and as this occurs mostly among the poor, a cheap but effectual remedy is most desirable.

Hydrochlorate or muriate of quina has the advantage of greater solubility than the sulphate, and seems, for this or other reasons, to possess a superior power over some forms of quartan ague, particularly of a typhoid type. Nitrate of quina is very insoluble in water, but easily so in alcohol. A tincture is therefore a good form. Phosphate of quina is equally and easily soluble in water and in alcohol—either may be used as its solvent. In the treatment of the nervous exhaustion of literary men, this preparation is of great utility.

Of the combinations of quina or cinchonia with organic acids the citrate seems entitled to preference. It is of great service. On account of its dearness sulphate of quina is often substituted for it; but when pure its curative properties seem very decided, especially against headaches of malarious origin. It may be taken along with lemon juice. [Orange.] A syrup also is formed, which is acceptable to children. Citrate of quinine and iron is a most eligible combination. Kinate and tannate of quinine are both useful forms. Arsenite and arseniate of quinine are forms of much utility, both in intermittent diseases and in skin affections, particularly if, in the latter cases, associated with sulphur.

Tartrate of quina is little known or used, except as a sulpho-tartrate above mentioned.

Acetate of quina is likewise little known, but an acetate of quinidina alone, which is less nauseous than the sulphate of quinidina, or in conjunction with this last preparation, is a very potent anti-periodic. Acetate of quina and iron is also a commendable tonic, especially in cramp of the stomach.

Valerianate of quina is liable to the objection that it has a most repulsive odour. But its efficacy as a tonic in nervous affections is very great; and in Asiatic cholera it has proved a useful support.

Hydriodate of quina is well suited to the debility of strumous persons.

Hydrocyanate of quina is well suited both for some cases of intermittents, in which the sulphate, from its heating properties, cannot be borne, and for all cases where a tonic and antispasmodic are indicated, such as convulsive disorders, St. Vitus' dance, &c.

Ferro-cyanate of quina is very soluble in alcohol, but not in cold water, while it is entirely decomposed by hot water. It is appropriate to tertian and quartan agues, especially where the sulphate cannot be borne.

Lactate, oxalate, and chloride are fitted for some peculiar cases, and have their respective advocates.

The ammoniated liquor of quina is one of the best preparations, and one of the most speedily acting. In severe influenza and depressed states of the system, it surpasses all other forms; but some persons cannot bear ammonia. Wines of quinine and wines of quinium exist, and are in request, but many owe as much to the wine as the quinine for the favour they enjoy.

Solutions of quinine, of hydriodate of quinine, and of valerianate of quinine in codliver oil are vended, but rapid decomposition occurs. So they should only be prepared immediately before they are to be taken.

QUINCE. The fruit so called is the *Cydonia vulgaris* of botanists, of which there are three varieties, the apple-shaped, pear-shaped, and the Portugal quince. The last is by some reckoned a species. There are also some sub-varieties of the others. The quince-tree is used, and chiefly propagated in this country, for furnishing stocks for grafting with such pears as are intended to be grown as dwarfs, or when early fruiting is desired. The Portugal quince is to be preferred for this purpose, as its growth corresponds nearer with that of the pear than the other smaller-leaved sorts. It is also better for the domestic purposes to which the fruit of the quince is applied, such as marmalade, and syrups or jellies. The propagation of the trees is easily effected by layering, but they root and grow slowly; and seedlings form the best stocks, though they require two or three years longer than these from layers before grafting. As the tree vegetates early, it should, when used as a stock, be grafted as soon as the weather will permit. From this not being attended to, a want of success has occasionally been complained of. The stocks should be headed down even as early as January. Quinces are best adapted for light and rather moist soils. In dry soils the pears grown upon them are rendered gritty. [Cydonia, in Nat. Hist. Div.]

QUINDECAGON, a figure of fifteen sides.

QUINETINE. [Cinchona, Alkaloids of.]

QUINIC ACID. [Kinic Acid.]

QUINIC ETHER. [Ethyl.]

QUINIA. [Cinchona, Alkaloids of.]

QUINICINE. [Cinchona, Alkaloids of.]

QUINIDINE. [Cinchona, Alkaloids of.]

QUININE. [Cinchona, Alkaloids of.]

QUINOIDINE. [Cinchona, Alkaloids of.]

QUINÖIL. Synonymous with Kinoil. [Kinic Acid.]

QUINOLINE. [Cinchona, Alkaloids of.]

QUINONAMIDE ($C_{12}H_5NO_2$), *Kinonamide.* An emerald-green crystalline product, obtained by the action of ammonia upon kinone.

QUINONE. Synonymous with Kinone. [Kinic Acid.]

QUINONIC ACID ($C_{12}H_4O_6$), *Kinonic Acid.* This acid has not yet been obtained in a separate state, but several of its derivatives are known. The following are the names and formulæ of the principal:—

Chloranilic acid	$C_{12}H_2Cl_2O_8$
Chloranilamide	$C_{12}H_4Cl_2N_2O_4$
Chloranilam or chloranilamic acid . . .	$C_{12}H_3Cl_2NO_6$
Chloranilammon or chloranilamate of ammonia	$C_{12}H_2(NH_4)Cl_2NO_6$

QUINONIC GROUP. [Kinonic Group.]

QUINOTANNIC ACID. [Tannic Acids; *Kinotannic Acid.*]

QUINOVATIC ACID. Synonymous with Kinovatic Acid. It is sometimes called chiococcic acid, and esculic acid.

QUINOVIC ACID. Synonymous with Kinovic Acid.

QUINSY, or Cynanche, or Angina, is an inflammation of the throat. Nosologists, having applied the name of cynanche to nearly all the inflammatory diseases in this part, have been obliged to distinguish the different affections of the several organs included in it, by specific names; hence we have *Cynanche parotidæa,* another name for mumps; *C. trachealis,* which is croup; *C. pharyngea,* or inflammation of the pharynx; *C. tonsillaris,* or inflammation of the tonsils; and many other species, named either from the organ chiefly affected, or the character of the inflammation. Of these, mumps and croup having been treated of in separate articles, the present may be devoted to the two last mentioned, which are indeed those that are commonly intended by the popular name quinsy.

Cynanche pharyngea, or inflammation of the mucous membrane lining the back of the mouth and the upper part of the throat, is that which usually exists in a common sore throat, brought on, as it most frequently is, by a change in the weather, or by sitting in cold or damp air. It is usually a mild disease, and chiefly annoying from its liability to recur on slight occasions. The extent of the inflammation varies greatly in different cases; it may be confined to the pharynx, or it may spread from it over the soft palate and the tonsils, and into the cavities of the nose, where it produces the additional symptoms of a cold, or into the tympanum, giving rise to deafness. On examination the back of the mouth and fauces, when thus inflamed, will be found unnaturally red and swollen, and often covered with tough mucus or lymph; and from these changes there result dryness and soreness of the throat, pain on swallowing, and a sensation as if the diseased parts were closely constricted.

A common sore throat does not need much treatment; warmth, gentle purgatives, and sweating medicines, the avoidance of stimulating food, and the inhaling of the vapour of hot water, or hot vinegar and water, or the application of a large poultice round the throat, will usually effect its removal in a few days. Sometimes however the disease is prolonged in a slight but obstinate form, which is commonly called a relaxed sore throat. In this condition the redness of the parts affected is still observed, but it is of a less vivid colour, and is irregularly streaky, instead of being evenly diffused; the velum also, which is commonly implicated, is elongated, and it is from its unnatural contact with the back of the tongue and the epiglottis that the tickling sensation in the throat arises, and excites a constant desire to swallow or to cough. For this condition the necessary treatment consists of stimulating gargles, such as hot wine, infusion of Cayenne pepper, very diluted mineral acids, &c., and if the patient be in general ill health, tonics and appropriate alteratives.

In more severe cases of inflammation of the pharynx and adjacent parts, matter sometimes forms either around or near the pharynx, or in the soft palate of the uvula, Wherever the existence of matter can be determined, it should be immediately let out, as from an abscess in any other part of the body. In other severe, and in some measure peculiar cases, the intensity of the inflammation is marked by the formation of false membranes on the affected surface. This form of the disease has been named *angina membranacea*, and has been especially described by M. Bretonneau and other French physicians under the name of *diphtherite*. [Diphtheria.] In its essential nature this affection resembles croup, with which also it is sometimes connected, the false membrane being not only spread over the mucous surfaces of the pharynx and fauces, but extending down into the trachea. In some cases the inflammation is very acute, and, being accompanied by common inflammatory fever, requires for its reduction the most active antiphlogistic treatment; the same measures, in short, as are applicable in cases of croup. [Croup.] In another severe form of quinsy, the inflammation and formation of false membranes are accompanied by a low typhoid state with great prostration of strength, and requiring all the remedies that are used in cases of low typhus fever, in malignant scarlet fever, and other dangerous diseases of the same class. It is this form of disease which is usually called putrid or malignant sore throat, and by nosologists, *Cynanche* or *Angina maligna*. It sometimes occurs as an epidemic, and was long regarded as attended by sloughing of the throat, the layers of false membrane being mistaken for the inflamed tissue in a state of gangrene. In other cases of this form of cynanche there is a tendency to the production of ulcers. These may be distinguished from diphtheria by the circumscribed character of the inflammation. The accompanying fever is of a more or less low form. The ulcers should be touched with nitrate of silver, and afterwards a most effectual remedy is a lotion of chlorate of potash with hydrochloric acid. In these cases the system requires support, and beef tea, port wine, and quinine should be administered.

In *Cynanche tonsillaris*, or tonsillitis, the inflammation is entirely or nearly limited to the tonsils. Its symptoms are scarcely distinguishable from those of the common form of the preceding disease, but on examining the throat the redness is seen to be less diffused, and the tonsils, being more or less increased in size, are approximated to each other so as nearly to block up the posterior aperture of the mouth, and render any effort to swallow extremely painful. Hence, to avoid the pain, the patient usually lets the saliva flow from his mouth, and often, in attempting to swallow, is unable to overcome the obstacle presented by the enlarged tonsils, and discharges the fluid back through the nose. In many cases also the inflammation extends to the eustachian tube and tympanum, producing deafness, and to the parts immediately around the larynx, giving rise to difficulty of breathing and a harsh hoarse sound of the voice. With these local symptoms there is usually more or less fever, with headache, loss of appetite, &c.

The milder cases of inflammation of the tonsils may be treated in the same manner as those of the preceding disease; leeches applied to the sides of the throat where the pain is most severely felt, are probably the most beneficial means that can be employed. The direct application of powdered alum to the tonsils is very useful. With a higher degree of inflammation abscesses often form in the tonsils, accompanied by all their usual signs, and with still greater obstruction in the throat. In time these will break of themselves, but it will materially shorten the patient's sufferings if they be opened as soon as matter has distinctly collected. The operation should be performed with a guarded knife, or with one that slips through a canula and can have the length of its cutting part fixed.

The most annoying result of repeated inflammation of the tonsils (and those who have once suffered are peculiarly liable to a recurrence of the disease from very slight causes), is, that they become permanently enlarged. In this state, although swallowing is not painful, it is often attended with difficulty, and by the partial closure of the fauces the respiration is always obstructed and requires an effort for its effectual performance. From this, in children, a peculiar deformity of the chest often results, the breast-bone and the fronts of the ribs becoming elevated and very much arched forwards, in a form which is commonly called chicken-breasted. But if this do not occur, the patient always suffers inconvenience from hoarseness and a kind of nasal sound of the voice; he cannot avoid snoring very loud in his sleep, and often starts up from it with a feeling of impending suffocation. The best means for the removal of this state are astringent gargles, as those with alum, oak-bark, mineral acids, &c. Iodine also, administered internally and rubbed on the throat, often proves useful; but in many cases nothing will alleviate the condition of the patient but cutting off a portion of each tonsil, so as to reduce them to their natural dimensions.

QUINTAL generally means the weight of a hundred pounds; but the term is not now English.

QUINTICHLOROPHENIC ACID. A product of the action of chlorine upon trichlorophenic acid [Phenylic Group], or upon chlorisatin [Indigo]. It is crystalline and volatile, and forms crystalline salts with bases.

QUINTILE, a term of astrology and ancient astronomy, meaning distant in longitude by 72 degrees, or the fifth part of the whole great circle.

QUIT RENT. [Rent.]

QUO WARRANTO. A writ in the nature of a writ of right for the crown, which lies against any person or corporation that has usurped or unjustly claims any public office or other franchise or liberty, or that, having originally had a grant of one, has forfeited it by abuse or neglect. Proceedings under it are prosecuted in the Queen's Bench, and the defendant is called on to show *by what warrant* (*quo warranto*) he exercises the office, liberty, or franchise in question. The first process against him is by summons. . If he fail to appear in the same term in which he is summoned, he loses his franchise. After appearance, he may disclaim any title, either to the whole or part of the franchise; or he may plead in justification, showing by what warrant he has exercised it. To this plea there may be either a demurrer or replication, and subsequent proceedings as in ordinary actions. On disclaimer judgment is immediately given for the crown. In that case, or on judgment for the crown on demurrer, or after trial, the judgment is that the franchise shall be seized into the hands of the crown, or, if the crown cannot have the franchise, that the defendant shall be ousted, that is, ejected. If the judgment be for the defendant, it is that he may enjoy the franchise, &c., saving the right of the crown, and this saving applies to all titles except that on which judgment is given. The judgment is conclusive even against the crown. (2 'Inst.,' 282; Co., 'Ent.,' 527, &c.)

Proceedings under a writ of quo warranto have, however, been superseded by informations in the nature of a quo warranto, these latter being adapted to attain the same ends, and, at the same time, more expeditious. The judgment is not in this case conclusive against the crown. Except when exhibited by the attorney-general, they are filed by leave of the court.

The statute of the 9 Anne, c. 20, was passed for the purpose of facilitating such proceedings in the case of corporate offices. For although their ostensible object is the punishment by fine, as well as the ejection of the usurper from his office, these proceedings are virtually of a civil nature, and are now almost exclusively employed for the decision of questions relative to the exercise of corporate rights between mere individuals. The prosecutor is styled the relator, and must apply by motion in open court for leave to file an information upon affidavits of all the facts upon which it is grounded. The court may either grant or refuse a rule nisi, and if a rule be granted, the case comes on for argument in the ordinary course. The defendant may then either support his opposition by affidavits stating the facts which form the grounds of it, or confine himself to arguments arising on the case presented by the relator. If the rule be made absolute, the defendant must plead, at latest, within the next term, but if the plea be insufficient, the court will allow the defendant to amend at any time before trial. In other respects, the pleading is conducted on the same principles as in ordinary cases. If the defendant be found guilty, the court may give judgment of ouster as well as fine. By the statute of Anne, costs are given to the relator against the defendant, if the information be successful; to the defendant against the relator, if it wholly fail. If one material issue be found for the crown, the crown must have judgment, and the relator is entitled to costs on all the issues. The provisions of the statute of Anne only relate to offices analogous to those mentioned, that is, those of a corporate character. By the statute 33 Geo. III. c. 58, the defendant is enabled to plead that he had exercised the office in question for six years previous to the exhibition of the information, and if the fact be so, he is entitled to judgment. By stat. 1 Vict. c. 78, s. 23, the time within which proceedings of quo warranto may be brought against any mayor, alderman, councillor, or burgess, is further limited to one year after either his election to office, or the commencement of his disqualification. (Com. *Dig.*, tit. Quo Warranto; Bl. *Com.*)

QUORUM. [Sessions.]

QUOTIENT, or **QUOTE**, the result of dividing one number by another.

R.

R is one of the vibrating letters called liquids. It is formed at the back of the palate, and is on this account more nearly related to the liquid *l* than to *n* or *m*. For the various forms of the alphabetical symbol see ALPHABET. It is convertible

1, with *l*. See that letter.
2, with *n*. See that letter.
3, with *rn* at the end of words. See N.
4, with *s*. See S.

5. It is apt to place itself at one time before, at another after a vowel. Thus in Greek *κροκοδειλος* or *κορκοδειλος*, *κρατος* or *καρτος*. So the English words *red*, *run*, are changed in the Dorsetshire dialect to *hird*, *hirn*. Again, *brid* is an old orthography of *bird*, and the town *Bridlington* is pronounced *Burlington*.

6. The letter *r*, in the neighbourhood of several consonants, is apt to disappear from words. Thus the German *sprech-en* is in English *speak*, our word *world* is in German *welt*.

7. In one language a word is found with an initial *r*, when in other allied languages there occur at the beginning two consonants, as *br*, *fr*, *wr*. Thus in Greek we have *ῥοδον*, *ῥηγνυμι*, *ῥεζω*, connected with which are the forms *βροδον*, *frango*, Latin, and *break*, English; and, thirdly, the English words *wreak*, *work*, *wrought*.

8. The letter *r* is at times confounded with *w*. Thus it is not a very rare variety of articulation that *rubbish* is pronounced *wubbish*.

9. More particularly when a word ends in a *w*, or even a vowel, it is not uncommon to pronounce an *r*, especially if the next word begins with a vowel. The London vulgarism, *winder*, *piller*, for *window*, *pillow*, is an example, nor need the philologist be ashamed to treat of such cases, which are as worthy of consideration as any dialect of the Greek tongue.

RABBI (*ῥαββί*, רַבִּי), a title of respect, similar in meaning to our word master or teacher, which was given to the teachers of the Jewish law by their disciples and the people in the time of Christ. (Matt., xxiii. 7.) The title was often given to Christ by his disciples. (Matt., xxvi. 25, 49; Mark, ix. 5; xi. 21; John, i. 38; iv. 31.) It is doubtful when it was first introduced. It is admitted by Jewish writers that it was not in use before the time of Hillel of Babylon, who lived in the 1st century before the Christian era; and it was perhaps first introduced into the Jewish schools about the time of Christ. The word was originally used in three forms: *Rab* (רַב), as the lowest degree of honour; *Rabbi* (רַבִּי), of higher dignity; and *Rabbun* (רַבּוּן), or *Rabboni* (*ῥαββονί*), which was the most honourable of all. The title of Rabboni is given to Christ on two occasions in the evangelists. (Mark, x. 51; John, xx. 16.)

The title of rabbi has continued in use among the Jews in modern times. The term rabbinical has been given to all the Jewish writings composed after the Christian era.

(Buxtorf, *Lexic. Chald. Rab. Talmud.*, 2176; Lightfoot, *Hor. Hebr. ad Math.*, xxiii. 7; Hill, *De Hebraeor. Rabbinis*, Jen. 1741; Winer, *Biblisches Realwörterbuch*, art. Rabbi.)

RABDOLOGY. [NAPIER'S BONES.]

RACEMIC ACID. [TARTARIC ACID.]

RACHITIS. [RICKETS.]

RACK. [ARRACK.]

RACK. [TORTURE.]

RADIATION OF HEAT is a motion of its particles in rectilinear directions, diverging every way from a heated body, either luminous or not; and it is imagined to arise from the existence of a strongly repulsive power by which the particles are made to recede from each other with great velocity.

The intensity of heat thus emitted from a point of radiation is obviously the same at equal distances from the point; and at unequal distances, it is inversely proportional to the squares of the distances. The radiating particles falling upon the surfaces of any bodies in the vicinity of that from which they emanate, are, according to the nature of those bodies, absorbed in them, or transmitted through them, or again they may be reflected from them; and, in the two last cases, the radiant heat, as it is called, appears to suffer modifications analogous to those which, in like circumstances, take place in light. According to M. Prevost ('Essai sur la Calorique Rayonnante,' 1809), the radiation of heat is a process which is perpetually going on among all the bodies in nature; those which are of equal temperature mutually interchanging equal quantities of caloric; but, with respect to two bodies which are unequally heated, that which has the greatest quantity sends forth emanations in greater abundance than the other; the difference however diminishing as both bodies approach to an equality of temperature.

The particles of heat (calorific particles) appear to move with perfect freedom through a vacuum, and to be impeded, but in an insensible degree, in their progress through air or any of the gases; they are also found capable of being transmitted, though in small quantities, through transparent media of the denser kinds, as glass, rock-crystal, &c.; and in passing through air they produce no sensible effect on the temperature of the latter. If a body be heated to any degree of temperature, and be placed in an absolute vacuum, it is evident that, in consequence of the repulsive power above mentioned, the heat must at length be entirely dissipated by the radiation merely; and if the body be placed in any fluid, it may be readily concluded that the abstraction of the heat must be influenced by the conducting power of the fluid.

The first direct experiments which appear to have been made on the radiation and reflection of heat are those of Mariotte, and an account of them is given in the 'Mémoires de l'Acad.,' 1682. He caused the heat of a fire to fall on the surface of a concave mirror, and observed that it was concentrated in the focus of the latter; and on placing a plate of glass between the fire and the mirror, he perceived that the rays of heat were intercepted. The subject does not appear to have been much attended to till about the middle of the 18th century, when Lambert, in his 'Photometria' (1760), states that, on placing a large glass lens before a fire, the heat was scarcely sensible at the focus, while the reflected heat of burning charcoal set fire to combustibles at a considerable distance; and Scheele, in his treatise on air and fire, which appears to have been written in 1775, describes radiant heat as differing from ordinary heat by disseminating itself in right lines whose directions are not changed by the agitations of the air, and by being reflected from polished metallic mirrors, while it is absorbed in those of glass, and in the others when their surfaces are blackened.

The experiments of Scheele were varied by MM. Saussure and Pictet, who by an appropriate apparatus endeavoured to ascertain the laws of the radiation of caloric. They employed for this purpose two concave mirrors of polished tin, in the focus of one of which was placed the bulb of a Réaumur's thermometer, and in that of the other a ball of iron heated below the degree necessary to render it luminous; and, by a comparison of the height of the mercury in the thermometer with that in one which was placed out of the focus, but at an equal distance from the iron, the difference was found to be equal to about 8 degrees. M. Pictet employed also, in place of the heated ball, a glass flask containing boiling water, in order to avoid the risk of any light being combined with the heat; and the effect produced on the thermometer sufficiently proved that the calorific rays exist independently of those of light. (Pictet, 'Essai sur le Feu,' 1790.) In pursuance of the experiments of Scheele with a blackened mirror, M. Pictet covered with lampblack the bulb of the thermometer in the focus of one of his mirrors, and found that the concentrated heat from the flask, which when the bulb was bright raised the mercury 2½ degrees, now raised it 4½ degrees. The same experimenter placed a flask of snow in the focus of one metallic reflector, and a thermometer in that of another; and the observed fall of the mercury was then considered as an indication that cold is susceptible of radiation and reflection like heat. The last experiment belongs however to an earlier date, as may be seen by reference to a letter from Oldenburg, dated 1665, in Boyle's Works (fo. 1744).

The nature of the apparatus, and the experiments made by Leslie on the radiation of heat, are described under HEAT. From these it appeared that the amount of radiation from a polished surface was only about one-eighth of that which took place from a surface without polish; and hence it was evident that the velocity of radiation depends more on the surface than on the nature of the radiating body. In making experiments respecting the absorbing power of substances, Leslie found that when the heat from the canister was suffered to fall on the glass bulb of the differential thermometer, the quantity received by the latter, if covered with tin-foil having a polish, was only one-fifth of that which it received in its ordinary state.

Leslie also repeated the experiments of Pictet for determining what was called the radiation of cold; and filling his canister with ice or snow, he found that the cold apparently emitted from the varnished side was the greatest, and that from the polished side the least; he observed also that the cold, like the radiant heat, varied with changes in the absorbent power of the thermometer and of the surface of the mirror. The mercury in the thermometer fell more when the mirror was of polished metal than when of glass; it also fell more when the bulb was in its ordinary state than when covered with a polished tin-foil. ('Inquiry into the Nature of Heat,' 1804.) These circumstances, which seemed at one time to favour the opinion that cold had a material existence like heat, have received an explanation from M. Prevost of Geneva. ('Journal de Physique,' xxxviii.) This philosopher observes that a mass of ice or snow may send out radiant heat less in abundance than that which is emitted from other bodies in its vicinity; and this comparatively small quantity of heat, when reflected from one mirror to the other, and from the surface of the latter to the focus, may there produce the effect of absolute cold, by causing the thermometer to send out radiant heat to the ice, and thus render the mercury in it lower than it would otherwise be. This interchange of caloric between the thermometer and the ice may be conceived to go on, the former on the whole losing, and the latter acquiring it, till an equilibrium is established between their temperatures.

From the results of Leslie's experiments, it is apparent that the power by which bodies absorb heat is directly proportional to that by which they allow it to radiate from them; and that both are inversely so to the power of reflecting it. When the rays of heat fall on polished glass, a large portion of them is absorbed; these raise the temperature of the glass, and from the surface of the latter that heat is afterwards radiated in abundance; whereas, when the rays strike the surface of polished metal, nearly all of them are reflected. It was found however that different metals, independently of their polish, have different degrees of reflecting and radiating power. A mirror of tin being rubbed with mercury, the reflection was increased in the ratio of 12 to 20, though the degree of polish was the same; and a metal having lost some of its brilliancy by oxidation, the radiating power was proportionally augmented.

Leslie's canister was found, moreover, to produce different effects, according to the thickness of the covering material on its sides. One coat of jelly on the tin side produced an elevation of the thermometer equal to 38°, and four such coats produced an effect equal to 54°; but after a certain thickness the difference was insensible. A plate of metallic leaf rendered however the radiating power as great as a thick plate of the same metal.

Experiments made by Count Rumford, soon after the publication of Leslie's work, produced nearly the same results as the latter had obtained; and the Count draws from them several useful conclusions. He observes ('Phil. Trans.', 1804) that when we would confine heated substances, solid or fluid, in a vessel, the surface of the latter should be highly polished; on the other hand, if the object be to cool the substances, the surface should be painted or varnished, or be covered with a soft coating which is not metallic. Also, in warming apartments by steam, the intention being to promote radiation as much as possible, the tubes conveying the steam should be unpolished or painted.

In pursuing the views of Scheele concerning the transmission of heat through screens, Leslie found that a sheet of tin interposed between the canister and the mirror entirely intercepted the heat, and a plate of glass nearly so. Employing two sheets of tin, each of which had one side covered with black varnish, while the other side was polished, the following were the results: when the varnished sides were in contact, little heat passed through, evidently because one of the exterior sides was not well adapted to receive the caloric, nor the other to radiate the little which might have been acquired; but when the varnished sides were placed exteriorly, the quantity which passed through was considerable, the varnish enabling one plate easily to absorb and the other as easily to radiate the heat.

The reality of the transmission of heat through glass plates, which both Leslie and Brewster appeared to doubt, from the difficulty of distinguishing between heat so transmitted and that which radiates from the glass after having been for a time absorbed in it, is now supposed to be sufficiently established by the experiments of MM. Prevost and De la Roche ('Annals of Philos.,' 1803), and also by the researches of M. Melloni. ('Annales de Chimie,' xlviii., &c.) The first, in order to ascertain the fact, received on a thermometer the rays from a heated body after passing through screens of glass which were renewed so often that they had not time to become heated. The second suffered a thermometer to rise to its maximum by the rays from a heated body when a transparent glass screen was interposed; and again, when there was interposed a glass screen blackened so as to prevent the radiant heat from passing, the excess of the rise of the thermometer in the former case above that in the latter gave evidently the effect produced by the radiant heat alone. The conclusion at which the experimenters arrive is, that the quantity of heat which radiates through glass is so much the greater as the temperature of the source of the heat is higher. M. Melloni found that of 100 rays incident on the same plate of glass from an oil-lamp, from red-hot platinum, from copper heated to 734°, and from the same heated to 212°, the numbers were 77, 57, 34, and 12, respectively. He has also ascertained that all bodies which have the power of transmitting heat are in general more or less transparent; and that rock-salt is the only known substance in which all the radiant heat falling on it is either reflected or transmitted, whether the temperature of the heated body be low or high.

Diathermacy does not depend upon transparency, either in solids or in liquids. An iron ball heated to 400°, placed midway between the blackened balls of a thermoscope, will not cause a rise in the liquid, since each bulb receives an equal share of heat; but if a plate of rock-salt be interposed between the iron and one of the bulbs, and a plate of glass of equal thickness between the hot ball and the other bulb, the bulb next the rock-salt will rise in temperature much more rapidly than the one next the glass, although both screens are equal in thickness, and equally transparent to light. So also, if four liquids equally transparent receive each 100 rays from an argand lamp, water will transmit only 11, sulphuric acid 17, ether 21, and oil of turpentine 31; while chloride of sulphur, which is of a reddish colour, allows 63 rays to pass. The diathermacy of different solids and liquids for heat from different sources is stated in a tabulated form in such books as Miller's 'Chemical Physics.' We do not repeat them here; but state a few of the more modern results given in that work in connection with the subject.

Knoblauch has found that very thin metallic films are diathermic, thus presenting an analogy to their limited transparency to light. Gold and silver transmit certain calorific rays more freely than others, while platinum appears to transmit all the rays with equal facility. Tyndall has found that the gases exert different degrees of absorptive action on the rays of heat; thus, coal gas is more absorptive than atmospheric air, and the vapour of ether considerably more than that of the bisulphide of carbon. Certain rays are more powerfully absorbed by the colourless gases than others. Thus coal gas arrests the heat rays from a source below a visible red heat much more perfectly than it absorbs the rays of the lime-light after they have traversed a thin layer of water.

Diathermacy is not dependent on transparency; thus black glass and plates of smoked quartz, so opaque that the midday sun is barely visible through them, are much more diathermanous than plates of alum; and plates of quartz smoked so as to be opaque are more diathermanous than when clean and transparent. Diathermacy seems to be more influenced by mechanical arrangement than by chemical composition. Common table salt is adiathermic: a solution of rock-salt is scarcely superior to pure water in diathermacy, and a solution of alum is equal to one of rock-salt. The latter substance in the solid colourless form approaches perfection in diathermacy as already noticed. But even this has lately been found to absorb certain of the rays of heat somewhat more freely than others. All other bodies examined by Melloni transmit a quantity of heat which varies with the nature of the source, just as coloured media transmit quantities of light depending on the nature of the colour. Thus if a pencil of solar light fall upon red glass, red rays alone will be transmitted, the rest being absorbed. This property, whereby different partially diathermanous media absorb different constituents of the thermic pencil, has been termed *thermo-chrosis* or "calorific tint." For as a pencil of solar light incident first on a red plate, and then on one of bluish green, will be totally absorbed, the second plate absorbing what the first transmitted, so a ray of heat may be entirely absorbed by causing it to pass through two media, one of which absorbs the rays transmitted by the other.

By letting the calorific rays pass first through one screen and then through two, M. De la Roche found that, in passing through the second screen, the rays suffered less diminution of intensity than in passing through the first; and the fact is considered as proving that some calorific rays experience more difficulty in passing through glass than others; consequently that, like light, radiant heat is of different kinds. He also observed that a thick plate of glass allows a smaller quantity of radiant heat to pass through than a thin one, and that the difference is so much the less as the temperature of the heated body is higher: and it is inferred that, since radiant heat becomes more capable of penetrating glass as the temperature increases, till the body becomes luminous, heat is only a modification of light.

The theory of radiant heat is intimately connected with that of the cooling of bodies; and the first effort to determine the laws relating to this subject was made by Sir Isaac Newton, who, from theoretical considerations, inferred that when a heated body is exposed to a constant cooling cause, as the uniform action of a current of air, it ought to lose at each instant a quantity of heat proportional to the excess of its temperature above that of the surrounding air, and consequently that its losses of heat in equal intervals of time should form a decreasing geometrical progression. But it is now known that this law holds good only when the differences of temperature do not exceed 40 or 50 degrees, and its inaccuracy at high temperatures was first pointed out by Martine (1740).

From the experiments of MM. Dulong and Petit, it is found that, if it were possible to obtain the absolute loss of heat which a body in vacuo experiences (or that loss which would take place if there were no restoration of heat from surrounding bodies), the velocities of cooling, estimated by the diminutions of temperature indicated by an air thermometer, would increase in a geometrical progression when the temperature of the heated body increases in an arithmetical progression; and further, that the ratio of the former progression (= 1·0077) would be the same for all bodies, whatever might be the state of their surfaces, and whether the temperature of the vacuum remained constant or increased in an arithmetical progression. But, on taking account of the quantity of heat sent back at every instant by the surrounding medium (a quantity which will be constant if the temperature of that medium does not vary), it is found that the velocities of cooling in vacuo increase, for equal increments of temperature, in a geometrical progression whose terms are diminished by a constant quantity, which quantity varies in a geometrical progression when the temperature of the medium varies in an arithmetical progression. By direct experiments on the cooling of heated bodies in air and hydrogen gas, Dulong and Petit determined what Leslie had before ascertained by an indirect process, namely, that the loss of heat when a body is in contact with a gas is independent of the surface of the cooling body. They found also, by experiments on dilated air and carbonic acid at various temperatures, that the velocity with which a body cools from the mere contact with gas (when the excess of temperature of the heated body above that of the surrounding gas is constant) depends on the density and temperature of that gas; but this dependence is such that the velocity of cooling remains the same if those elements change in such a way that the elasticity of the gas remains constant. The same chemists have also ascertained that, when the elasticity of air varies in a geometrical progression, its cooling power varies likewise in a geometrical progression, in such a manner, that when the common ratio of the first progression is 2, that of the latter is 1·366. If, instead of common air, hydrogen gas, carbonic acid, or olefiant gas be in contact with the heated body, the ratio of the first progression being as before, that of the second is 1·301. And they conclude that the cooling power of each of the last-mentioned gases is nearly proportional to the square root of the elasticity of the gas. ('Annales de Chimie,' vii.; 'Annals of Philos.', xiii.)

That the colours of bodies have some effect on the velocity of radiation and on the absorption of heat has been proved by experiments made by Dr. Stark of Edinburgh (1833). This gentleman surrounded the bulb of a thermometer successively with equal weights of black, red, and white wool, and placed it in a glass tube, which was heated to the temperature of 180° by immersion in hot water; the tube was then cooled down to 50° by immersion in cold water, and the several times of cooling were respectively 21, 26, and 27 minutes. On winding successively black, red, and white wool about the bulb, and raising the temperature from 50° to 170°, the times in which the thermometer so surrounded acquired the latter temperature were respectively 4½, 5½, and 8 minutes. (Turner's 'Elements of Chemistry,' Heat.) Mr. Glaisher ('Phil. Trans.' 1847) found the order of the radiating power of coloured wools exposed to a clear nocturnal sky to be *black, green, white, crimson, scarlet, orange, yellow, dark blue, light blue*, the difference between light blue and black being 1°·3.

The refrangibility of heat was first examined by Dr. (afterwards Sir William) Herschel, who, having analysed by the prism, as usual, a beam of solar light, and having placed a Fahrenheit's thermometer successively within the fields of the different coloured rays in the spectrum, found that in the violet rays the temperature was 2°, and, gradually increasing towards the other extremity, in the red rays it was 7° above the general temperature of the apartment. He also ascertained that there was a point beyond the limits of the visible red rays at which the excess of temperature was a maximum. Similar observations were made about the same time by Sir Henry Englefield; and it was hence evident, not only that the calorific rays were refrangible, but that the property existed in them in a higher degree than in light. Dr. Herschel afterwards made a number of observations on small pencils of heat proceeding from a lighted candle, a common fire, iron heated to redness, and also from iron heated to a lower degree; and he discovered that, in all these cases, the calorific rays were susceptible of refraction. He found however that there was some difference between the heat of the sun and that of terrestrial bodies, the former passing more freely through the glass than the latter. ('Phil Trans.', 1800.) M. Melloni has subsequently ascertained, by using prisms of rock-salt (a mineral which possesses in a high degree the power of transmitting heat), that heat from different sources, like light of different colours, has different degrees of refrangibility.

In the experiments on radiant heat it has been noticed, that when such heat from whatever source has been once absorbed and again radiated it does not retain the peculiarities of its source. But heat of low refrangibility may be converted into that of higher refrangibility.

M. Berard ascertained that when light suffers double refraction in Iceland spar, the two pencils formed spectra which exhibited similar properties; in both, the calorific power differed at the two ends, and existed beyond the visible red rays. Also, on polarising by reflection from glass a beam of solar light, and receiving the reflected ray on a second glass, the latter being capable of turning round till the ray ceased to be reflected from it, he found that while the light was reflected, the heat was also reflected, and that when no light was reflected, there was no heat. The like effect was produced when, instead of a pencil of solar light a portion of radiant heat from a body not luminous was employed, and the inference is, that the particles of radiant heat are polarised by reflection, like those of light. This subject has however been since more completely investigated by Professor Forbes, ('Edinburgh Phil. Trans.', 1835.) Knoblauch, ('Pogg. Annal,' lxxiv.) has also obtained distinct evidence of the diffraction and interference of the rays of heat.

The subject of solar radiation, or of the direct force of the sun's rays, so important to the agriculturist as well as to the philosopher, was treated by Mr. Daniell, in his 'Meteorological Essays,' 1823. On comparing a thermometer exposed to the action of the sun with one which gave the mean temperature of the air in the shade, Mr. Daniell observed that the power of solar radiation varies with the sun's declination; the greatest intensity taking place in June, though the greatest mean temperature of the atmosphere does not occur till July. He observed also that the radiation varies at different hours of the day, increasing with the sun's altitude till a short time after it arrives on the meridian, and then diminishing till the evening. From the observations of Major Sabine at Sierra Leone, at Bahia, and at Port Royal, Daniell was led to conclude that the intensity of solar radiation diminishes in proceeding towards the equator; and the conclusion appears to have been subsequently confirmed by the observations of Scoresby and Parry, and of Richardson, in the Arctic regions. From the observations of Sabine on the mountains of Jamaica, Daniell considers that this radiation increases from the surface of the earth upwards. [Actinometer.]

Since all bodies, even in vacuo, lose heat by radiation, it is easy to conceive that any part of the earth's surface, when not exposed to the direct action of the sun, must emit calorific rays of heat towards the heavens, and thus must become cooled. This is called *terrestrial radiation*, and the subject was particularly considered by Mr. Daniell, who, from observations continued during all the months of the year, found that the maximum depression of the thermometer, on account of radiation, varied from 10° to 17° between midwinter and midsummer; but that the mean depression was the least in January and July, and the greatest in April. It is obvious however that numerous observations are yet to be made in different regions of the earth before any general theory respecting the extent and law of the variations of solar and terrestrial radiations can be formed. The progress that has been made on the subject of late years is noticed under Meteorology; Temperature, Terrestrial, Distribution of.

RADICAL. [Root.]

RADICALS, ORGANIC. [Organic Radicals.]

RADISH. Of this vegetable there are several sorts. The *Scarlet* or *Salmon-coloured*, and the *Radis rose demi-longue*, are the best for early sowing; the latter variety is very tender and of a fine bright colour. The purple, another early long-rooted variety, is sometimes sold under the name of *Salad Radish*, the seed leaves being larger and consequently better adapted for small salading than those of the other varieties. With the colour of the preceding sorts, the *Long White Transparent* will form an agreeable contrast. Of the round or turnip-rooted varieties, the *Early White Turnip-rooted* and the *Purple Turnip-rooted* are the best. The *Yellow Radish* succeeds in hot weather, being fit for use when the earlier kinds are apt to run to seed; and it precedes the autumn and winter varieties, of which the following is the order of succession: *Round Brown, White Spanish, Oblong Brown, Black Spanish*, and *Purple Spanish*. None of these are however esteemed in this country, where they are generally unknown.

If the early white turnip-radish be sown in August, it will come into use in the spring. The principal sowings should however be made in January and February, and successionally till May. The winter varieties require to be sown in July. In cold frosty weather the beds should be protected by straw, as is commonly practised, or by such other efficient means as may be at command. The covering should be always dispensed with when the days are fine; but it ought to be replaced before the cold of night ensues. With careful management they may be gathered nearly throughout the year, but in a hot autumn it is difficult. Radish seed-pods are sometimes pickled, whilst tender, and may be used instead of capers, when the latter cannot be obtained.

RADIUS (a ray, the spoke of a wheel) means the line drawn from a point, considered as a centre or pole, to any point of a curve.

RADIUS OF CURVATURE. [Curvature; Surface.]

RADIX (root) is applied to any number which is arbitrarily made the fundamental number of any system. Thus ten is the radix of the decimal system of numeration, and the radix of the common system of logarithms. The term however has not acquired much fixed use, though often convenient for temporary specification of the use which is made of a particular number or fraction.

RAGGED AND INDUSTRIAL SCHOOLS; REFUGES FOR DESTITUTE CHILDREN. Efforts to instruct ignorant and neglected children are not peculiar to the present time, although such efforts have been of late years more systematic and sustained than formerly. The Sunday schools now so numerous in this country commenced with what were in effect ragged schools. About sixty years ago, Thomas Cranfield, in conjunction with a few other persons connected with Surrey Chapel (Rev. Rowland Hill's), commenced a "Fragment school" in the Mint, Southwark, which was followed by the opening of other schools, similar to the present ragged schools. John Pounds, a cobbler, of Portsmouth, gathered neglected children into his workshop, and in this humble way was able to impart the rudiments of education to about five hundred children. About 1839, efforts were put forth in Bristol and in London to establish schools for the neglected and outcast. Andrew Walker, an agent of the London City Mission, opened schools of the kind referred to in Westminster, and similar schools were soon after commenced in other parts of London, till, in the course of five years, when the Ragged School Union was formed (1844), there were 20 schools, with 200 voluntary teachers and about 2000 scholars.

Ragged Schools are generally intended to impart instruction, chiefly religious. At first they were usually open during the week in the evening only, besides being open on Sundays. It was considered best to commence the experiment with the evening school, as many of the children had to provide for themselves the means of living by selling articles in the streets, and most of them were unwilling to submit to the restraint of school hours during the day-time. This system was found, in the course of a few years' experience, to work very imperfectly, and paid teachers were in many cases engaged to conduct the schools. Such schools were opened during the day as well as in the evening. In many schools industrial day and evening classes were also added; and in some, food, to a small extent, was given to the scholars. In order to obtain more complete control over the children, *Industrial Feeding Schools* were established, in which the children are taken charge of for the whole of the day, supplied with food, instructed in the ordinary branches of common school education, and taught some handicraft. The credit of originating this system is by common consent awarded to Sheriff Watson, of Aberdeen, and the schools founded by him are generally regarded as models. *Refuges* are industrial feeding schools in which the children are also housed and clothed. *Reformatories* are similar to refuges, with this difference, that the children received into reformatories are such as have brought themselves under the operation of the criminal laws of the country, and are, by authority of the magistrates, placed under instruction and discipline, not only for their own benefit, but likewise for the protection of the community. [REFORMATORIES.]

In connection with the London Ragged School Union, at the commencement of 1860 the number of schools held on Sunday afternoon and evening was about 200; of scholars, more than 22,000. Of day schools, there were 146; of night schools, 200. Of industrial classes, there were 114. About 1500 children were sent to situations during the year 1859. There were 2670 voluntary teachers, 380 paid monitors, and 416 paid teachers. The paid teachers have an association for mutual benefit, by means of which new modes of teaching and other improvements are communicated to the members. There were 76 penny banks, with upwards of 15,000 depositors, with an amount approaching 9000*l.* paid in during 1859. In 49 clothing clubs sums amounting to nearly 600*l.* were contributed by the subscribers for the purchase of articles of wearing apparel. In connection with the operations of the Union, there were 93 Ragged Church and City Mission meetings held weekly, and 75 meetings for the benefit specially of the fathers and mothers of the children attending ragged schools. During the year, 132 scholars had become voluntary teachers, and 88 were received as members of Christian churches. The aggregate income of 155 schools for 1859 was upwards of 17,000*l.*, and that of 15 refuges was more than 15,000*l.* The expenditure of the Ragged School Union was about 5000*l.* During the year, 282*l.* 13*s.* had been given by the Union in small sums as prizes to scholars who had retained situations for more than twelve months.

The Western division of the metropolis contains 39 ragged schools, with upwards of 4200 children. Of these schools, 8 are in Westminster, 5 in Chelsea, 1 in Brompton, 5 in Paddington, 2 in Bayswater, 5 at Notting Hill, and 2 at Hammersmith.

The Central and Northern division comprises 38 schools, with about 5500 children. These schools are pretty equally distributed over the district, which is an extensive one, reaching from Bedfordbury, Covent Garden, to Hoxton, and from Clare Market to Agar Town. Five of the schools are in the vicinity of Drury Lane and Lincoln's Inn Fields; 2 in and near Seven Dials; 5 in Field Lane, Saffron Hill, and Clerkenwell Green; 3 in Camden Town; and 10 in Islington.

The Eastern division includes 38 schools, with about 6000 scholars. Of these schools, 2 are in the City, 5 in Whitechapel, 7 in Spitalfields, 4 in Bethnal Green, and 10 in the neighbourhood of the Docks, Ratcliffe Highway, Shadwell, and Poplar.

In the Southern division are 40 schools, with about 5500 children. Two of these schools are situated in Lambeth; 3 in the vicinity of the New Cut; 7 in the Borough; 4 in Newington and Walworth; 5 in Bermondsey; 6 in Rotherhithe, Deptford, Greenwich, and Blackheath; 2 at Peckham; 2 in Camberwell and Brixton; and 2 at Clapham.

Bristol was amongst the foremost in dealing with an unhappy juvenile population by the agency of the ragged school. The name of Miss Carpenter, as a writer and as an active worker, is necessarily associated with this good work in the city where she resides. Few persons have done more to advocate the claims of the children of the ragged school than this energetic and benevolent lady. The Bristol ragged school for males and females, established in 1846, has accommodation for 150; the Bristol industrial school for males, established in 1849, for 50. At *Liverpool* the first ragged school was established in 1844. In 1848 a Ragged School Union was formed. This union comprised, at the commencement of the year 1860, 60 schools, of which 33 were evening schools, 12 day ragged schools, 3 industrial schools, and 12 Sunday schools only. The aggregate attendance of scholars was 6974; the number of teachers 483; and of monitors (in the day ragged schools) 20. During the year 489 obtained situations. In eight of the evening schools, at which the aggregate attendance was 378, a charge of a penny a week is made to the scholars, who are generally ragged school children who have gone to situations. Several of the schools have penny banks in connection with them. *York* industrial ragged school, commenced in 1846, has accommodation for 100 orphans, destitute children, and vagrants. *Manchester* possesses a ragged and industrial school at Ardwick Green, commenced in 1846, with accommodation for 300 poor and vagrant children and unconvicted juvenile thieves, from which, since its commencement, about 500 children have gone into situations. In connection with the Manchester and Salford Ragged School Union, formed in 1858, there are 15 schools, with an average attendance on the Sunday evenings for the year 1859 of 3564 children, with 426 teachers. Each school has one or more evenings in the week devoted to secular instruction, with attendance, in all, of 1916. During the year more than 200 scholars were transferred to Sunday-schools of a higher class; 60 were sent to day-schools, and 65 obtained situations. The penny banks connected with the schools received upwards of 200*l.* from nearly 1200 depositors. In *Birmingham* a ragged and industrial school was commenced in 1846. The free industrial school, commenced in 1849, provides for 12 children of both sexes. *Bath* established industrial schools in 1843; *Derby*, *Hull*, *Ipswich*, and *Sunderland* in 1849; *Cambridge* in 1850; *Chester*, *Clifton*, and *Gloucester* in 1852; *Bolton* in 1853; and others followed in quick succession. At *Bradford*, where the first ragged school was established in 1855, there were in that year 111 cases of juvenile delinquency. In 1856 the number fell to 76; in 1857 to 47; and in 1858 to 26. These results are ascribed to the operation of the ragged school.

In Scotland the subject of juvenile delinquency was first dealt with in the city of Aberdeen, where vagrancy and street begging, with their usual accompaniment of petty pilfering, had become formidable nuisances. With 100*l.* subscribed by himself and some friends Sheriff Watson commenced in October, 1841, an industrial school for boys. The number of scholars at starting was 20. Two years later a similar school was opened for girls. Another, called Sheriff Watson's Female School of Industry was opened in April, 1847, with 53 children. The juvenile school of industry was commenced in 1845, in co-operation with the police authorities, who underook to send to the school every child found begging in the streets. At the end of 1846 was instituted the Child's Asylum, the committee of which investigates the cases of begging and delinquent children, and hears applications from parties for the admission of destitute children into the schools of industry. The children are instructed in reading, writing, arithmetic, geography, geology, and religious knowledge. The boys are employed in net-making, which is found to be a healthy as well as a remunerative occupation; and they occasionally work in the garden. In the girls' schools the scholars do all the household work; they receive an education similar to that which the boys receive; and they are trained for domestic service. The present state of the Aberdeen industrial schools is as follows:—

Schools.	Average Number on Roll.	Average Monthly Attendance.	Average Cost of each Child during the Year.
			£ s. d.
Boys' industrial school . . .	79	70	3 12 6
Juvenile industrial school, boys .	67	62	3 18 0
Juvenile industrial school, girls .	60	58	
Female school of industry . . .	100	95	4 2 10
Sheriff Watson's female school of industry	63	56	4 15 3½

It is scarcely necessary to remark that juvenile begging has been entirely got rid of in Aberdeen, and that the number of juvenile criminals is very greatly reduced. In 1841 the number of juvenile offenders in prison was 61; in 1858 it was 15. Upwards of 3000 children have attended the Aberdeen industrial schools since their commencement. Of these 200 girls have gone from school into domestic service, and 400 boys into situations, and are, with few exceptions, known to be doing well: many have been taken home by their parents.

The *Dundee* industrial school, accommodating 200 boys, was founded in 1846, and has been extremely beneficial to that town. *Glasgow* commenced the work in 1847, and has six industrial and reformatory schools, with accommodation for more than 1000 children. The Act 17 & 18 Vict. cap. 74, applicable to Scotland, which was passed in 1854, provides that children, apparently under 14 years of age, found in a state of vagrancy, may be brought before a magistrate, and sent to an industrial school. This Act, commonly known as 'Dunlop's Act,' has been found exceedingly useful in Glasgow, as well as in other large towns in Scotland. It has been ascertained that the amount of juvenile begging has been materially lessened since the Act referred to was brought into operation. The industrial school at *Ayr* was founded in 1848; those of *Greenock* and *Stirling* were commenced in 1849; of *Kilmarnock*, *Paisley*, and *Stranraer* in 1850; and many others have been opened since.

The industrial schools of *Edinburgh* owe their formation chiefly to the exertions of the Rev. Dr. Guthrie of that city. The success of the efforts at Aberdeen and Dundee prompted Dr. Guthrie to take measures for forming an industrial feeding school in Edinburgh. An interim committee was formed, and public attention and sympathy were engaged by the publication of Dr. Guthrie's first 'Plea for Ragged Schools.' The scheme received general support, and was speedily put in operation. Another industrial school was also commenced by other influential persons in Edinburgh. Dr. Guthrie's first 'Plea' was followed by a second, and the two have been recently republished with a third 'Plea,' under the significant title of 'Seed-Time and Harvest; or Pleas for Ragged Schools.' The results in the decrease of juvenile mendicancy and crime have been most striking and satisfactory. From the Original Ragged Schools, 536 have been sent to situations, including those who have been sent out as emigrants, and those who have gone into the army and the navy; from the United Industrial Schools, 461.

About three years ago, cards of invitation to a tea-meeting were issued to as many of the old scholars of the Original Ragged Schools as could be found in Edinburgh. It was a very pleasant and joyous assemblage. About 150 attended, some of the guests being the wives, and others the husbands, of former scholars. Dr. Guthrie says: "We lingered over the scene. Nor could I look on that gathering of young men and women—so respectably clad, and wearing such an air of decency—and think what, but for the ragged school, they would have been, without tears of joy, gratitude to God, welling up to the eyes. It was a sight worth living for. It was our harvest home."

In Ireland not many ragged schools have been instituted, and most of the industrial institutions now in operation are of recent establishment.

The Mill Street ragged school in Dublin was commenced in 1851. Up to 1858 the average attendance of children at the Sunday schools varied from 149 in one year to 360 in another; in 1858 the number was 110. At the daily school for boys and girls, the average attendance varied from 60 in 1851 to 80 in 1858. A ragged school, dormitory, and industrial home for boys, was commenced in 1853, for the benefit especially of destitute and homeless boys attending the ragged school. During 1859 there were 75 boys admitted; of these 22 went to situations.

The following *Refuges*, in connection with the London Ragged School Union, had a total of 605 inmates in March, 1860. The figures appended indicate the number of children in the respective refuges:—

For boys:—Belvedere Crescent, Lambeth, 19; Bridge House, Wandsworth, 70; Britannia Court, King's Cross, 14; Brook Street, Hampstead Road, 18; Bryan Street, Caledonian Road, 32; Euston Road, 51; Great Queen Street, Lincoln's Inn, 100; Grotto Passage, High Street, Marylebone, 22; Hatton Street, Maida Hill, 28; Mansell Street, Whitechapel, 47: total, 401.

For girls:—Albert Street, Mile End New Town, 38; Broad Street, St. Giles's, 52; Hill Street, Dorset Square, 60; Lisson Street, Paddington, 33; Manor Street, Chelsea, 21: total, 204.

From these refuges, during the year, 182 obtained situations, 49 were sent out as emigrants, and 80 were otherwise provided for. A new Home of Industry for Females was opened in October, 1860, at Old Pye Street, Westminster.

The largest Refuge in the metropolis is that in Great Queen Street, Lincoln's Inn Fields, entitled the St. Giles and St. George, Bloomsbury, Refuge for Homeless and Destitute Boys. It was commenced in 1852, in Arthur Street, St. Giles's, with about 20 boys. In 1858 it was removed to extensive premises in Great Queen Street, formerly occupied as a coach factory. The number of boys at present in the house is about 100. They are employed in shoemaking, tailoring and other handicrafts, the return for which lessens the expense of the boys' maintenance. The same society has a refuge for 50 girls in Broad Street, Bloomsbury, and supports several ragged schools. The total number of children admitted into the two refuges up to the end of 1859 was 781; namely, 469 boys and 312 girls. Of the boys, 89 emigrated to Australia, Canada, the United States, and South Africa; 34 entered the navy; 15 entered the merchant service; 76 were placed in situations; 41 were restored to their parents and friends; 2 were apprenticed; and 3 enlisted. Of the girls, 99 were sent to service, 88 were restored to their friends, 13 removed to other institutions, 5 emigrated to Australia, 26 to Canada, 16 to New Zealand. Numerous and satisfactory communications have been received from and respecting the emigrants. Connected with the boys' refuge is a Band of Hope, the members of which are instructed in the principles of temperance, and are trained in singing, in which many of the boys attain great proficiency, and several obtained silver medals in a public competition for singing and recitation.

A source of great anxiety to the conductors of ragged schools is the disposal of the children after they have been in some degree fitted for active life; and emigration, assisted as this has been to a large extent by the government and by private benevolence, has opened an eligible outlet for many hundreds of the children. Many encouraging reports have been received respecting the conduct of the emigrants. Mr. John McGregor, barrister, who has taken a deep interest in all the efforts for the benefit of ragged school children, visited Canada in the autumn of 1858, and made it his business to institute personal inquiries into the condition of boys who had been sent out as emigrants from metropolitan refuges and ragged schools. The result of his inquiries was extremely favourable, many of the boys being found in good situations, and conducting themselves in a creditable manner. The letters from emigrants which are published in the annual reports of the Red Hill Reformatory, the St. Giles's Refuge, and similar institutions, contain much that is interesting and indicative of well-doing on the part of the writers.

An excellent initiatory step in industrial training has been found in connection with the shoe-black brigades. The shoe-black societies were commenced in 1851. For the year 1859 the statistics of those in London were as follows:—

Name of Society.	Uniform.	No. of Boys.	Earnings.
			£
Ragged School Shoe-black Society .	Red.	59	1,746
East London	Blue.	106	1,094
South London . , ...	Yellow.	40	669
North-West London . . .	White.	16	140
West Kent	Green.	13	120
West London	Purple.	15	206
Islington	Brown (red facing)	26	240
Notting Hill	Blue (red facing)	26	200
Union Jack (Limehouse) . . .	Red (blue facing)	18	133
		319	4,548

Besides these societies there is a Roman Catholic brigade, designated as that of St. Vincent de Paul.

The result of the establishment and extension of the ragged school system may be summed up in the terms of a resolution, moved by Sir J. P. Kaye Shuttleworth, at a meeting of the Leeds Ragged School and Shoe-Black Brigade, in October, 1860, with Viscount Palmerston, prime minister of England, in the chair:—"The establishment of ragged schools has been productive of much good in diminishing crime and ignorance; and a large extension of this species of benevolence is imperatively demanded in our large and populous towns and cities."

RAGS. Until some better and cheaper material can be discovered, linen and cotton rags will continue to be the staple of the PAPER MANUFACTURE, as described in the article under that name, and will continue to be an object of great solicitude to governments and manufacturers. Linen rags are imported mostly from Hamburg, Bremen, Rostock, Ancona, Leghorn, Messina, Palermo, and Trieste. Those from the first three ports are mostly German rags; those from the next four are Italian and Sicilian rags; while Hungarian rags are shipped at Trieste. The rags are closely packed in bags of about 4 cwt. each; and the bags are marked according to quality. The foreign rags are darker, dirtier, and coarser than English; but as they comprise a larger ratio of linen and a smaller of cotton, they are better for the paper-maker's purposes than English rags—especially as they can now be bleached as white as the latter by boiling in a ley, and then exposure to chlorine. Holland, Belgium, Spain, and Portugal, as a means of protecting the paper-manufacture, prohibit the exportation of rags altogether; and France is only now (1860) beginning to depart from that system, as one of the counterbalances for the advantages she receives through the new Commercial treaty with England. The United States compete seriously with England for the purchase of European rags, and overbid her for those of Northern Italy. Taking an average of recent years, the price paid by English paper-makers for foreign rags ranges between 20*l.* and 30*l.* per ton, including freight. When England made 120,000,000 lbs. of paper annually, she used 10,000 tons of foreign rags; if the same ratio prevails now, when the product reaches 210,000,000 lbs. (as it did in 1859), the foreign rags must be nearly 20,000 tons; but there are reasons for thinking that the English portion of the supply, owing to the greater use of cotton and straw, has increased faster than the foreign.

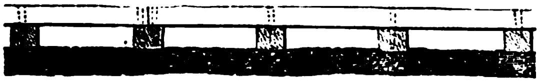
Woollen rags are not available for paper-making. If of loose texture and not too much worn, they are reserved for *shoddy;* that is, they are torn up by machinery into fibres, and mixed with new wool to make cheap woollen cloths. Some of the *pilot* cloths, as they are called, now made in enormous quantities about the neighbourhood of Dewsbury and Batley, consist of three-fourths or seven-eighths shoddy, with only a small proportion of new wool. Some of the woollen rags are made into flocks for beds, by washing, grinding, tearing, and pulping. All that is too bad for these purposes is used as manure. Besides our own woollen rags, the chief foreign supply is from Hamburg and Bremen. The prices are generally about 15*l.* or 20*l.* per ton for good white, 10*l.* or 12*l.* for good coloured, and 5*l.* or 6*l.* for common.

RAILWAY. A road in which smooth tracks of wood, iron, stone, or other suitable materials are introduced for the purpose of obviating the friction of the wheels of the carriages to a greater extent than can be done on common roads. Railways are thus of various kinds, and they have been used for a very considerable time as a means of diminishing the cost of transport of minerals and of heavy goods. Of late years they have been applied to the general purposes of intercommunication, in conjunction with the locomotive engine, and the improvement in all social relations thus effected has been so great, that it has almost formed a new era in the history of our race.

As the construction of railway carriages, and of the engine power employed for moving them, are subjects intimately connected with the formation of the road itself, and indeed regulate some of its most important details, it appears desirable to discuss them at the same time as the railway itself is under consideration. It is intended, therefore, to present a brief sketch of the progress of invention in matters connected with railways; an account of the general mode of designing and executing the works of the substructure, and of the roadway; an account of the usual modes of working a line of railway; and a few of the statistics of the railways already executed at home or abroad.

History.—In the cities of Northern Italy the practice of laying smooth tracks of hard marble in the ordinary paving of the streets, which prevails in those cities to the present day, appears to have been applied for many centuries; but the use of railways, properly speaking, cannot be traced farther back than to about the year 1680, when, in the neighbourhood of Newcastle-upon-Tyne, some roads with wooden rails were laid down (*figs.* 1 and 2), for the purpose of facilitating the transport of coals from the pits to the landing stages. For many years this imperfect system of road making continued in use without improvement, and it was not until about the year 1716 that a raised rail, protected by flat iron on its upper surface, was introduced in those parts of the road where the traction was the heaviest. The next improvement consisted in the substitution of the edge rail for the flat band screwed down to the wood, and the durability of these rails was further increased by the use of cast- instead of wrought-iron. The waggons which ran upon these rails were usually loaded to the extent of from two to three tons, and the traction was performed almost entirely by horses, unless, in a few cases, wherein the carriages were allowed to descend some inclined planes by the effect of gravity. The introduction of the cast-iron edge rail appears to have taken place about the year 1767, at the suggestion of Mr. Reynolds, the engineer of the first cast-iron bridge erected in England, in the Colebrook Dale.

Fig. 1.



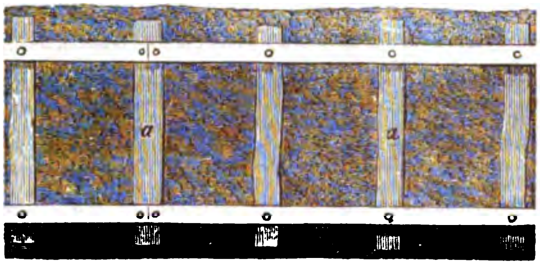
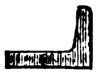


Fig. 2.

Fig. 3.



The next step in the history of railways was made by the application of a cast-iron plate in a kind of ⌋ form, instead of the straight cast-iron edge rail (*fig.* 3); this alteration was said to have been suggested by the manager of the Duke of Norfolk's collieries near Sheffield, in 1776, and the system itself is still retained in mining operations. The rails, in all the forms originally applied, were laid upon wooden sleepers (*fig.* 4); but about 1793, stone blocks were used to support the rail, and this apparently unimportant change, by rendering the first cost of an edge railway, and its subsequent repairs, less expensive than before, tended greatly to facilitate the introduction of the new system. Very shortly after the substitution of the stone blocks for the wood sleepers, the coalowners of Northumberland and Durham introduced the use of cast-iron edge rails in short lengths, but fastened to chairs let into the stone blocks; and in this manner they succeeded in obtaining a roadway upon which the traction was comparatively easy, at a very trifling expense (*figs.* 5 and 6). The rails were cast in lengths of from 3 to 4 feet, and they were made in what is called the *fish-bellied* form, or with their greatest depth in the middle; *a* represents (*fig.* 5) the section of the rail in the middle, and *b* the section at the ends; the latter were made with a half-lap joint, and through this joint a key was passed to fasten them to the chairs. The friction upon these edge rails was further diminished by making the tires of the wheels slightly conical. Many of the mine railways are even at the present day made precisely in this manner; and so great was found to be the advantage the cast-iron edge rails produced, that several roads were laid down in various parts of the kingdom, about the beginning of this century, in which they were employed. The old Croydon railway, and the tramway laid down in the Commercial Road, London, may indeed be referred to as illustrations of the importance attached by our immediate predecessors to the necessity for diminishing the cost of goods traffic, and of the earnestness of their efforts to attain such results. Animal power was, however, the only one used until about 1810; so that the rapidity of intercommunication could hardly have been much affected by any of the systems applied up to that period.

Fig. 4.

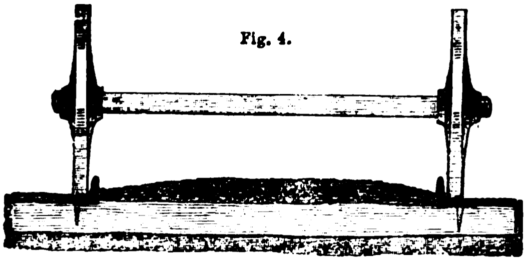


Fig. 5.

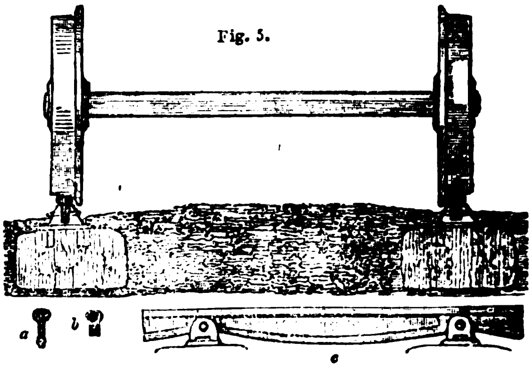
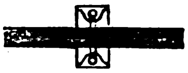
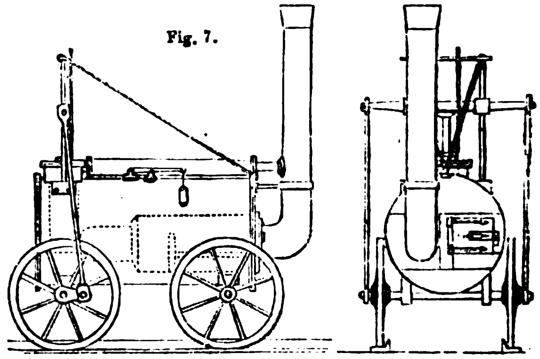


Fig. 6.



Although the application of steam, as a motive power to the carriages running upon railways, has been of a comparatively-speaking recent introduction, the efforts of mechanicians had long been turned towards that object. Watt, Symington, Trevithick, Blenkinsop, Chapman, Brunton, and others, had striven for more than forty years to discover the means of propelling carriages by steam upon common turnpike roads, or upon railways; but after numerous failures, the whole class of machine-makers seem, about the year 1812, to have arrived at the conviction that a simple band wheel could not exercise a sufficient amount of friction upon a road surface to cause the carriage to advance. For many years the efforts of steam-carriage builders were directed to obviating this imaginary difficulty, and rachet wheels, jointed levers, mechanical legs of every shape and form, were introduced, to the detriment of the roadway, and to the diminution of the useful power of the engine. About 1814, however, George Stephenson constructed for the Killingworth Colliery, Durham, a steam-engine, bearing two cylinders seated upon a boiler mounted on wheels, and immediately above the axles of those wheels, which bore cranks connected with the piston heads of the cylinders, and were made to revolve in unison by means of vaucanson chains working over barrels on the respective axles. The engines made upon Stephenson's principles were not at first much esteemed, and it was long before they became of general use; but gradually they were adopted in the colliery districts; and about the year 1826, Stephenson even applied one of them for passenger traffic on the Stockton and Darlington line. The velocity attained by these engines was not more than about nine miles an hour, when used for passenger traffic; or than five miles per hour for goods.

Fig. 7.



Trevithick's Engine.

One of the great inconveniences felt in the early days of the use of the locomotive, arose from the number and the insecurity of the joints of the rails when the cast-iron fish-bellied ones were employed, and from the brittle nature of the iron itself. The discovery by Mr. Birkenshaw of a mode of efficiently and cheaply rolling malleable iron rails, which was patented by him in 1820, constituted, therefore, a most important link in the chain of mechanical invention, by whose means the railway system has been perfected. The fibrous character of the wrought-iron makes it far less likely to break under concussions than cast-iron would be; and the sectional form generally given to the H or double-headed rail, offers a very great resistance to deflection. It is remarkable that rails which are constantly travelled over do not rust; but it is important that they should be made of a metal as crystalline as it possibly can be, consistently with the retention of its malleability; soft, fibrous iron is, in fact, not suited for the manufacture of rails. Wrought-iron rails are made about 15 or 21 feet in length, instead of 3 or 4 feet, as in the case of the cast-iron rails.

When the projectors of the Liverpool and Manchester Railway were engaged in the design and execution of that great work in the year 1825, and the following years, the capabilities of the locomotive engine were still so little known that it was for a long time a matter of discussion whether or not that description of motive power should be adopted. The directors were soon convinced that horse-power would not enable them to attain the speed they considered necessary; but the result of the experiment upon the Stockton and Darlington line had not been sufficiently decisive to induce them at once to try the new locomotives. They therefore consulted some of the most eminent engineers of the day, and after carefully examining the reports of Messrs. Rastrick and Walker in favour of fixed engines, and those of Messrs. Stephenson and Locke in favour of locomotives, the directors wisely determined to use locomotives, and to offer a premium for the best engine of that description which should fulfil certain conditions. The history of this competition is so well known that it would be useless to repeat it here; and it may suffice to observe that the premium was won by Messrs. Stephenson and Booth, who produced the Rocket engine, of which an illustration is given (*fig.* 8); and thus inaugurated the most important revolution in the means of material civilisation which any age has witnessed. [STEPHENSON, GEORGE, in BIOG. DIV.]

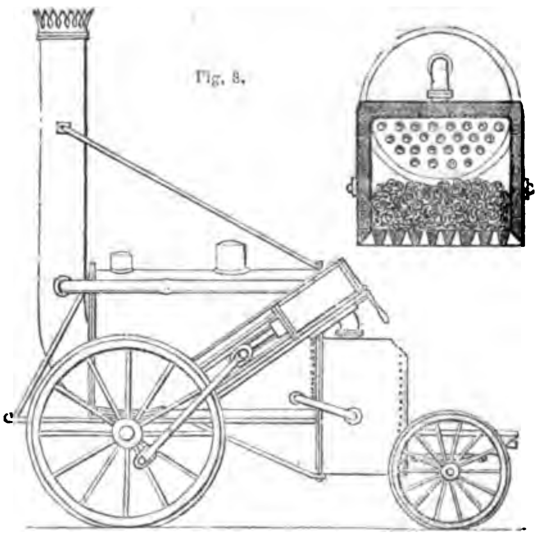
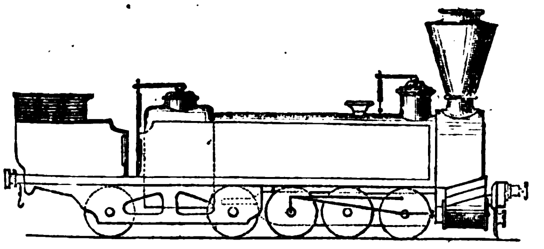


Fig. 8.

The French mining interest had not neglected to avail themselves of the advantage offered by the edge rails in diminishing the cost of their heavy traffic; and they had constructed about 1826, the railways from Roanne to St. Etienne, and from St. Etienne to Lyon and to Andrezieux. M. Sequin, the engineer of one of these lines, had also constructed some locomotive engines for the purpose of drawing the waggons; and in them he first introduced the use of small tubes passing from the fire-box to the chimney. Messrs. Stephenson and Bury adopted this plan in constructing the boiler of the Rocket, and thus increased in a notable manner the evaporating power of their engine; and they increased the draught by causing the waste steam to escape by the funnel. The cylinders of the Rocket were fixed externally; a system to which after many trials some engine-makers seem disposed to return; and the early locomotives invariably were heated by coke. The Rocket had four wheels, not coupled, and its weight was only 4 tons 5 cwt.; it attained with a gross load of 17 tons, an average speed of 14 miles, and in some instances it attained a speed of 17 miles per hour. It is curious to contrast these figures with the ones connected with the more recent locomotives. Thus, the weight of some of the passenger engines on the North Western line (without their supplies of coke and water) is not less than 27 tons; the weight of some of those on the Great Western line is not less than 31 tons; and some of the engines used on the Sœmering line are even of 48 tons weight and have six coupled wheels. The various considerations connected with the weight and the dimensions of locomotives belong however to the records of the subsequent history of the railway system; its general (or perhaps rather its preliminary) history was closed by the triumphant success of the Rocket.

Fig. 9.



On the modes of designing and executing the works upon railways.—(*Organisation.*)—It would serve little good purpose to discuss here the question as to whether or not it would be desirable to charge the central administration of a country with the duty of laying out the lines of railway communication; because the peculiar circumstances of every nation will, generally speaking, render the solution of that question independent of any abstract reasoning. No doubt the absence of anything like administrative control has led in England to a fearful waste of money, and to the establishment of a ruinous competition in many instances; but if we had waited until the government had decided upon the merits of railways in the first instance, or until it should have decided the precise routes to be followed by the new lines of intercommunication in the second, it is tolerably certain that we never should have possessed the marvellous instruments of civilisation we actually do. The results of the intervention of the state authorities in other countries do not seem to warrant the belief that, in the end, they manage things better than is done here; and practically it has been shown that the "laisser aller, laissez faire" system conduces the most surely, not only to a nation's greatness, but even to the extent and the perfection of its railways. At any rate our trunk railways are made, and it would be useless now to attempt to retrace our steps. In our colonies there may be reason, and there still is time, for the government to interfere, to guide the efforts of capitalists, and to spare them from the robbery and extortion they certainly have been exposed to in England. But the author of this notice, who has had a long practical experience in foreign countries, feels it at once to be his duty to record his conviction, that no more mischievous course can be adopted than for the government of any country to execute, or to work a railway; either when the question is considered from a structural and engineering point of view, or from a political, or moral one. Perfect freedom of private industry *may* lead to abuses; the creation of a number of places of pay and profit *must* do so, however honest the chiefs of an administration may be.

However the management of the general system of the railways of a country may be settled, the first questions which require consideration, when it has been determined to execute a line between any two important termini are, whether or not it should be made to deflect a little, in order to accommodate the local traffic; or whether it would be preferable to serve that traffic by means of branch lines. The relative importance of the intermediate towns and the, so to speak, locomotive habits of their inhabitants, must be taken into account in arriving at the decision on this subject; as must also be considered the pecuniary circumstances of the local travellers, inasmuch as the latter materially affect the relative proportions of the persons taking the various classes of carriages. On short railways the local traffic will be found to vary between from 60 to 90 per cent. of the whole receipts; on long railways the through traffic bears a larger proportion to the total receipts, and this probably as much on account of the increased number of first-class passengers, as on account of the increased total number of passengers. The usual relative proportions of the travellers in the various descriptions of carriages is in England as follows: in the first class there are about 13·2 per cent., in the second there are 31·2 per cent., and in the third 55·6 per cent.; in Germany these proportions do not hold, for the first-class passengers are fewer, and the second-class ones have a much greater relative importance; these differences may to some extent be explained by the character of the accommodation given, but the comparative wealth of the population to be served must also influence them. The probable amount of the local goods traffic must be taken into account likewise in estimating the influence of any particular place on the prosperity of a line; and above all things an estimate of the cost a passage through it would entail must be made. It would appear that the average distance traversed by a ton of goods on lines of considerable length is about double the distance travelled by ordinary passengers, and that goods travel a relatively greater distance on long lines than they do upon short ones. As a general rule, the result of the most careful investigations of the traffic returns of railways has been to show that it is not desirable to sacrifice local traffic to the interests of the termini; and the history of some of our "direct lines" proves that whenever the communication between the termini is sufficiently important to justify a direct railway, the want will very soon be supplied. There are some curious statistics on this subject in Lardner's 'Railway Economy,' and in Perdonnet's 'Traité Elémentaire des Chemins de Fer.'

The principal points through which a railway is to pass being thus settled, it is necessary carefully to examine the country to be traversed, its relief, its means of transport for the materials required, its rivers, roads, and canals, both on account of the facilities they may furnish, and of the works they may render necessary, and its geological structure, both superficial and subterranean. If this inquiry should not lead to the discovery of any special necessity for carrying the line in a definite direction, it should, of course, be made as straight and with as near an approach to a dead level, as is possible. In the early days of railway making greater importance was attached to the latter condition than is now the case; and in France, even as late as in 1846, Mr. Locke had great difficulty in persuading the authorities to tolerate inclines of a rise of 1 in 126; but upon the Birmingham and Gloucester line, the Lickey incline with a gradient of 1 in 37, has been for years in successful work, and in the passage of the Sœmering, on the Vienna and Trieste railway, the inclines are sometimes carried for great distances, at the rate of 1 in 40, and the radii admitted in the curves upon the level parts are often not more than 623 feet, whilst upon the inclines of 1 in 40 they are still occasionally of only 934 feet; the length of the arcs in the latter cases does not exceed 1300 feet in round numbers. Of course the speed over lines with inclines of so severe a nature cannot be great, but the introduction of the expansion gear into the locomotive has so much increased what may be called the elasticity of its powers, that at the present day an incline of 1 in 100 would not be regarded as unfavourable, and the former limit of 1 in 200 would not be a matter of a moment's hesitation. Curves of 800 feet radius are often resorted to, when, on account of the approach to a station, the speed of a train must be slackened; but it is hardly safe to admit them of a less radius than of about ¼ of a mile on the ordinary parts of the line.

The limits of incline above quoted are the maximum ones which can be worked economically by locomotive power, and whenever it might become necessary to overcome differences of level, which could not so be passed, it would be indispensable to resort either to the use of inclined planes, or to tunnel through the hill which interposes itself. The mechanical principles upon which these considerations mainly turn are, firstly, that upon a railway the traction does not exceed ⅐th of the effort required to move a load on a level and well-made turnpike road; or as the traction on the latter is as 1 te 30 of the load, it is on a railway as 1 to 210 or to 250; at an inclination of 1 in 250 it is already about as 1 to 100; and it thence rapidly increases until with an inclination of 1 in about 150 a well-made carriage would, if left to itself, descend an incline by the mere effect of gravity; or, in other words, the force required to draw the load up the incline must not only be in excess of that required to overcome the friction, but also to raise a portion of the dead weight of the train. The practical questions connected with the nature of the inclines admissable on a railway, it may be added, may often be materially affected by the use of bank engines upon the heaviest part of the inclines; but however the difficulties of such inclines may be obviated they must always constitute a burden upon the working expenses of a railway, so that they should never be admitted unless at the last extremity. As far as possible alternate directions of inclination should be avoided, and the rise should take place as nearly as may be to some engine station, whence a supplementary engine could be obtained if needed. Curves of small radius are nearly as unfavourable to the economical working of a railway as are heavy inclines, and they therefore should only be resorted to in the last extremity.

The only other special considerations to be taken into account in the laying out the plans of railways are, firstly, that they should cross existing roads as seldom as possible on a level; and secondly, that the stations should be made in positions where they can easily be approached. All that relates to the execution of embankments, bridges, viaducts, culverts under or over passages, resembles so closely the same description of work required in ordinary engineering operations, that they may fairly be discussed under the exclusively practical section of the formation of the road.

Obtaining an Act of Parliament.—As the railways in England are constructed by associations of private individuals, with a view to their own pecuniary advantage, as well as with a view to the public benefit, it is necessary that, on the one hand, legislative restrictions should be imposed to protect the interests of all who may, either directly or indirectly, be affected by the execution of such works; whilst, on the other hand, the promoters of the scheme should be protected against the imposition of the landowners, and should be vested with the necessary powers to carry their scheme into effect, if the legislature should consider it to be advisable. Lands, buildings, water-courses, canals, roads, &c., have from time to time to be interfered with; and whilst justice requires that the various parties interested in them should be fairly and liberally indemnified for any loss accruing to them or to their property, either directly or contingently, and that every unnecessary interference with the existing rights of property should be avoided, it is equally necessary for the public benefit that operations of this description should not be defeated by objections inspired by prejudice, or by mistaken private interest. It has been with a view of reconciling both of these conditions that the Houses of Parliament have issued a code of instructions, known under the name of the *standing orders*, for the purpose of affording the parties interested the means of stating their respective cases before the tribunals appointed to examine the necessity for the legislative powers sought to be obtained; and although there are no doubt instances in which great apparent injury is thus inflicted, on the whole the system of referring railway bills to select committees of the two Houses has (to quote a well-known phrase) "worked well." The opportunity thus afforded for factious opposition is, perhaps, one of the worst evils attending this system of legislation; and it often leads to a frightful expense. The act for the London and Birmingham Railway cost at least 72,000*l.*; that for the Great Western, cost 88,000*l.*; and that for the Brighton Railway, a still larger sum. The standing orders and the legislation of railway companies have been frequently modified; but at the present day they may be stated to be (briefly) as follows.

Bills for the establishment of a joint-stock company for the execution of a railway, or for the increase of the powers of any existing company, are of the second class of private bills. Notices of the intention to apply to parliament for the necessary powers must be given once in the months of October and November, or in one of them, in the London, Edinburgh, or Dublin Gazette, and in three consecutive weeks in some one and the same newspaper of the county in which the lands such bill refers to may be situated; if the works should extend over more than one county, then the notices must also appear in the journals published in London, Edinburgh, or Dublin, as the case may be. Notices are to be given, in writing, to the landowners, lessees, and occupiers, of the intention to apply for the bill, and these notices must be served before the 15th of December previous to the session in which the application to parliament is to be made. Plans and books of reference of the lands and houses to be taken, together with a section of the intended line, are to be deposited before the 30th of November with the clerk of the peace, or the sheriff clerk, of the respective counties traversed, with the Board of Trade, and at the private bill offices of the Houses of Parliament; and in cases where it is proposed to execute works upon tidal lands, within range of spring tides, similar plans and sections have to be deposited with the Board of Admiralty. The petition for the bill is to be deposited at the Private Bill Offices on or before the 23rd of December, and it must be accompanied by a declaration from a parliamentary agent, and a copy of the proposed bill: in the declaration by the agent, he shall distinctly state the class of the bill, and the powers sought to be obtained by it. Printed copies of the bill must also be deposited with the Board of Trade, on or before the 23rd of December; and with the Admiralty, if necessary. Copies of the estimates, declarations, lists of owners, lessees, and occupiers, are to be deposited at the Private Bill Offices on or before the 31st of December; and in cases wherein new companies are proposed to be established, a declaration must be made, stating the amount of capital, the number of shares to be issued, the number subscribed for, and the number paid up. In some cases, copies of the last-named documents are required to be deposited also at the Vote Office. The plans required are to be drawn to a scale of 4 inches to a mile, and must show the line or situation of the whole work, and the lands, &c., it is intended to traverse; and whenever it is proposed to apply for powers to make lateral deviations, the limits of those deviations must be distinctly indicated. Enlarged plans of buildings, court-yards, gardens, &c., to a scale of not less than ¼ of an inch to every 100 feet, must be added; the distances from one of the termini must be indicated in miles and furlongs; those portions of the line which are to be executed in tunnel must be indicated by dotted lines; and every deviation or alteration of turnpike or other roads, of rivers, or of canals, must be clearly set forth. The book of reference must contain the names of the owners, lessees, or occupiers of the houses and lands to be interfered with, and it must contain a description of the nature of the property to be taken. The sections are to be drawn to the same horizontal scale as the plan, and to a vertical scale of not less than one inch to every 100 feet; they must show the natural level of the ground, the intended level of the work, the relative heights of the embankments and cutting, the datum line, and the rails' level; the height and span of the various bridges, viaducts, &c., are to be indicated, as also are to be indicated the alterations proposed to be made in the levels of the existing roads or other communications. The estimate must be signed by the person making it. In the case of railway bills, a deposit of 8 per cent. on the amount of the estimate must be made before the 15th of January.

The details of the preliminary requirements of the legislature, stated above as being necessary before the bill can be entertained, are extracted from the standing orders of the House of Commons; but, according to May's 'Parliamentary Practice,' the requirements of the two Houses are identical, excepting in some insignificant matters of detail. The further stages of the proceedings, it may be added, are described upon the supposition that the bill sought for is presented, firstly, to the House of Commons.

Any person interested in the proposed railway, or in its operation, is entitled to present a memorial in opposition to its progress, on the ground of non-compliance with the standing orders, before some day between the 9th and 23rd of January, according to the number of rotation assigned to the petition for the bill. The examiners of petitions for private bills then inquire into the manner in which the standing orders have been complied with; and, if any irregularity should have been committed, they make a report to the House of Commons, or send a certificate to the House of Lords, to the effect that the standing orders have not been complied with, but they do not at all enter into the inquiry as to the merits of the bill. If the standing orders should, however, have been complied with, a report is made to that effect. Within three days from the date of the indorsement of the bill by the examiner of petitions, the petition for its being read must be presented by a member, and it must be accompanied by a printed copy of the bill; and if the standing orders have been complied with, the bill is at once ordered to be brought in; if they have not been complied with, the petition is referred to the standing orders committee, who are empowered to make special reports to the House on such subjects. The second reading of the bill takes place at some period between the third and seventh day from the first reading, and is considered substantially to sanction, in the opinion of the House, the principle of the bill, which is then committed. It is firstly referred to the general committee on railway and canal bills, which names the chairman and members of the select committee before whom the examination into the allegations of the petition and the clauses of the bill takes place. The select committee must consist of five members not locally or otherwise interested in the bill, when the latter is opposed; or the bill may be referred to the chairman of ways and means and to two members, when it is unopposed. After an interval of eight days at least from the second reading, the select committee proceed to hear the parties who seek the act, and those who have petitioned against the bill, either by themselves, by their agents, or counsel; and after a careful examination of the evidence submitted to them (in the House of Lords the evidence is taken upon oath), the committee are bound to report upon the various subjects involved. These subjects mainly affect the fitness of the proposed railway in an engineering point of view, the peculiar local circumstances affecting the works, and the main allegations of the petitions for or against the bill, with the reasons of the committee for agreeing to or dissenting from them. The committee is bound not to authorise a company to raise a larger sum by loan or mortgage than one-third of the capital; and until 50 per cent. of the capital has been paid up, the company is not to be allowed to raise any loan. No alterations of turnpike roads are to be allowed which should leave the rate of inclination of the new road more than 1 in 30; nor shall any other road be made, without special reason, whose incline shall exceed 1 in 20. Numerous provisions are made also by the instructions of the House for the purpose of preventing any abuse of the powers to be conferred by the bill, or of preventing the smuggling of clauses for one object under cover of a bill avowedly proposed for another one. It is worthy of remark that amongst these instructions, which in fact constitute the standing orders to the committees, there is one whose object it avowedly is to prevent the payment of interest upon deposits, or payments on calls, until the line is opened—a course of proceeding diametrically opposed to the one followed by all other countries in Europe. The usual course of the inquiry before the committee, so as to enable them to make their report to the House, is to discuss firstly the preamble of the bill; and, if that should be declared to be proved, then to discuss the clauses seriatim. In this manner the whole of the measure is capable of being thoroughly examined, and the obnoxious portions can be removed if the parties really interested attend to their own business; the principal difficulty, however, attending all these proceedings lies in their cost.

When the report of the select committee has been made, the committee clerk delivers into the Private Bill Office "the committee bill," which is printed at the expense of the parties, and delivered to the members of the House. The report of the bill is ordered to lie upon the table, as also is the amended bill; and after the interval of three clear days from the delivery of the report the consideration of the bill may be proceeded with, on the third reading. So jealous is our legislature, *theoretically*, of the rights of private property, that it is easy, even at this stage, to stop the progress of a bill; but, in fact, it is very rarely that the decision of a select committee is reversed. The usual course is, that the bill, as it leaves the committee, passes on the third reading; and it then has to go through nearly a similar ordeal in the House of Lords; and, unless important amendments should there be introduced, the bill receives the royal assent, and becomes an Act of Parliament. The proceedings before the House of Lords differ in some respects from those which are followed before the House of Commons; but the differences consist mainly in points of form, and they seem to have been inspired principally by the desire of the former House to protect in the most efficient manner the vested rights of property. The reader who would desire to study more in detail the law and the practice of Parliament in these matters, would do well to consult the work by Mr. May before referred to, and to read the Standing Orders published by the respective Houses of the legislature at the commencement of each session. Amongst other provisions made by the House of Lords, there is one it may be important here to notice—namely, that they fix at the commencement of every session a day beyond which they will not take any proceedings in private bills, whencesoever proceeding. Mr. May's work contains also an ample description of the fees payable to the officers of the respective Houses of Parliament, a study of which might fairly be recommended to the attention of the administrative reformers of the day.

Owing to the numerous subjects embraced, a railway act is always a lengthy document; but of late years these measures have been considerably simplified by the passing of the Railway and of the Lands Clauses Consolidation Acts. In cases where companies simply apply for powers for increasing their capital, or when they apply for powers of amalgamation, or purchase of other companies, the forms of parliamentary practice are slightly different from those above described; and the Wharncliffe standing orders prescribe the observance of certain conditions under the peculiar circumstances they were designed to meet, especially with reference to the manner of ascertaining the opinions of the shareholders of any existing company as to the extension of their operations. The principle of this legislation is, however, on the whole, extremely equitable, and it substantially affords protection to existing interests, whilst it gives every reasonable facility for the development of enterprise.

Formation of the Road.—The Act of Parliament being obtained, the land required for the railway is definitively set out and purchased. Power is usually given to take a width of 22 yards, exclusive of that which is necessary for the sloping sides of cuttings or of embankments; and it may be added that, in ordinary cases, the average quantity of land taken is about at the rate of 12 acres per mile lineal of road, leaving out of account the stations, when the latter are of considerable importance. The price to be paid for the land is either settled by amicable arrangement, or it is fixed by a jury; and it includes all claims for compensation, severance, and compulsory purchase. It appears that, practically, railway companies are compelled to pay about double the real value of all the land or hereditaments they take—so deeply rooted is the popular opinion that the interests of private individuals should be studied at the expense of public companies.

The works themselves connected with the formation of the road consist in the embankments and cuttings, the tunnels, the bridges, viaducts, and culverts, and the stations and minor accessory buildings. These works are usually divided into separate contracts, and are let by public or by private competition, unless when—as is far too often the case in England—the bulk of the capital has to be provided by the contractor. In ordinary cases, the works which would take the longest time are commenced the first, especially when it is desired to open the line at once in its entire length. Before any works, however, are commenced, it is essential to make a series of deep borings wherever important structures are to be raised or tunnels to be formed; the result of the preliminary observations upon the Kilsby Tunnel seem, indeed, to show that these borings should be made very close to one another, and that they should be carried at least to the maximum depth it may be desired hereafter to attain. Careful observations must also be made upon the hydrographical conditions of the country to be traversed, the inclination of the strata, and their hydroscopic nature, not only for the purpose of dealing with the springs they may yield, and their greater or lesser tendency to floods, but also in order to provide against any danger from the slipping of the earth. It must be observed here that tunnels upon railways are objectionable, on account of their darkness, their dampness, and the singular interference they produce with the action of the electrical telegraphs, as well as on account of the special attendance they require. As far, therefore, as possible, they should be avoided; nor should they ever be resorted to in the open country where land can be obtained cheaply, unless the cutting it would otherwise be necessary to make should exceed 80 feet in depth. In towns, of course, the value of land will materially affect this question, and, as in the case of the Underground Railway, it may even be desirable to execute nearly the whole of the line in tunnel. [TUNNEL.]

The angle of inclination of the slopes of cuttings should be made to vary with the nature of the material traversed. Hard limestone or sandstone rocks will stand when dressed off vertically; chalk and the softer limestones will ultimately assume a slope of about 45°, or of 1 base to 1 vertical; hard gravel, bound together by waters containing the hydrous oxide of iron, will stand at a similar inclination to chalk, but the ordinary open gravel and sand, without water, should be dressed to a slope of 1½ base to 1 in vertical height; the London, Oxford, and Gault clays may sometimes stand with an inclination of 2 or 3 to 1, but if they should contain any beds of permeable sand they have been known to slip even with inclinations of 10 to 1. Wherever moveable strata of this description are encountered, the greatest precautions must be taken to provide an efficient surface drainage, so as to prevent the passage of water to the more permeable lower strata. The danger arising from the tendency of some materials to slip after the condition of stability they have naturally assumed has once been disturbed, is principally felt when the cutting has to be made on a hill side, and when it lays bare the lower edges of inclined beds of sand or of gravel intercalated between beds of clay. In many cases, it is better to construct at once a retaining wall than to trust to any form of slope; but the thrust of a lofty bank of earth, such as is now under consideration, must be so enormous that especial precautions must be taken to guard against its effects, and to provide an outlet for the waters which would otherwise accumulate at the base. The history of the New Cross cutting, near London, of the Euston cutting, of the London end of the Great Northern Railway, of the Kilsby cutting, and of the cutting near the Val Fleury, on the Versailles line, may be cited as illustrations of the accidents to which deep cuttings are exposed, and of the means of obviating them. Much information on this subject is to be found in Sganzin's 'Cours de Construction,' and in

Perdonnet's 'Traité' already referred to. In settling the amount of cutting to be executed on a line of railway, it is essential to bear in mind that it should, as nearly as possible, balance the amount of the embankment so as to avoid either the necessity for purchasing ground to receive the spoil or surplus earth, or to furnish the material for the completion of the bank from side-cutting. The Tring cutting on the Birmingham Railway, and the Gadelbach cutting on the Ulm and Augsburg line, are amongst the largest works of this description yet executed: the former contained nearly 1½ millions of cubic yards; the latter about 1,410,000 cubic yards.

The embankments are formed simultaneously with the cuttings, and the materials obtained from the latter are transported by barrows, carts, or waggons, to the former, according to the distance; barrow-work ceasing to be economical when the distance to be traversed exceeds 100 yards, carts are then used; and when the length of transport attains a quarter of a mile it is decidedly cheaper to use waggons upon temporary roadways, made in railway works of the metals, or rails, to be afterwards used for the permanent way. As embankments can thus only be commenced from their two ends at a time, it follows that when they are of considerable dimensions they may even regulate the duration of the works upon a railway, because bridges or tunnels can be commenced at once in several places. Time may occasionally be saved by the use of temporary wooden staging, and by carrying on the work in several layers or strata; but if the length of lead (or the distance traversed) be great, it is very rarely indeed that more than from 2000 to 2500 yards cube can be tipped at one end of a bank in a day. The earth in small banks is often rammed to ensure its uniform compression, and even in the very rough and ready manner in which railway works are effected, especially in England, the precaution of punning the earth at the back of culverts, or bridges, is generally adopted. For large embankments it would be practically impossible to attempt to secure this theoretical perfection, and the earth is in them simply cast, or tipped, from a waggon, and is allowed to settle by its own weight, and by the effect of time. It is important, therefore, to observe that the earth taken from a cutting will, in the beginning, occupy a space about ¼ greater in the bank than it did in its natural position; and that even after they have settled during three or four years the materials in a bank will still occupy a volume ⅛th greater than they did originally. The subsidence of new-made banks is indeed a source of danger and of expense on all railways, and it must be guarded against in the most careful manner; allowance should be made for such subsidence, by keeping the crowns of the banks above the intended finished level.

In executing heavy embankments care must also be taken to ensure that the ground upon which they are to be founded should not be exposed to lateral displacement, or to any serious amount of vertical compression; although the latter objection ultimately resolves itself simply into a question of money. Accidents of this description frequently occur upon the banks of rivers, or in alluvial districts; and the most efficient mode of dealing with them is to isolate the seat of the bank from the surrounding ground, in such a manner as to cause the whole compression to take place vertically. In marshy and boggy grounds judicious drainage may do much good; but the system adopted in carrying the Liverpool and Manchester Railway over the Chat Moss, of supporting the earth to be deposited upon a stratum of hurdles, or the one used by the Dutch engineers of forming as it were a floor of fascines, or of bundles of reeds, must in many instances be resorted to in addition to the introduction of lateral drains. On the Munich and Augsburg line an efficient method of carrying the railway embankment over a peat-bog about 16 feet deep was used, which it may perhaps be desirable to mention here; it consisted in sinking a series of square holes, "en echiquier," about 2 ft. 10 in. apart, and measuring 1 ft. 9 in. square at the bottom, and 2 ft. 10 in. square at the top; these holes were then filled with impermeable earth, and the embankment was laid on them; the seating of the bank was first properly drained and a good outfall provided. Another class of positions in which it is necessary to take especial precautions in forming embankments, is when their feet are exposed to the action of large bodies of water, whether tidal, flowing, or comparatively still, as in lakes. The materials used below the water-line should be of the greatest possible specific gravity, the seat of the bank should be cleared, by dredging, of all loose or compressible mud, and the sides exposed to the wash of the water should be protected by beds of fascines, or by stone pitching in ordinary cases; in sea water, or in open bays, it may even be necessary to carry the foot of the embankment upon solid masonry walls. [EMBANKMENT; RIVER; WEIR.]

The earth-works upon most of the principal lines in England have been very heavy, and they seem in some exceptional cases even to have cost 20,000*l.* or 30,000*l.* per mile; nor has it been by any means rare for the average cubical quantity of earth so moved to average from 100,000 to 150,000 yards per mile. In other countries this portion of the cost of railways has been diminished; first, by reason of the lower price of labour; but secondly and principally, by reason of the facilities afforded by the steeper gradients now tolerated.

There are some minor works usually included in the description of the excavator's department in the construction of a railway, which are of sufficient importance to require notice. These are the fencing in of the land; the formation of the cop mound, and of the ditch; the planting of the quickset hedge; and the soiling and planting of the slopes. Insignificant as these works may seem to be in themselves, much of the security from accidents of the railway depends upon their being well executed and well maintained; and it is especially on account of habitual disregard the American engineers display to the safe enclosure of their lines, that the accidents from strayed animals occur so frequently with them. The planting of the slopes of embankments, it may also be added, is an easy and profitable mode of protecting them.

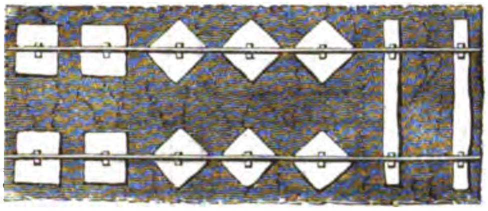
Bridges are required on railways for the purpose of carrying them across the various water-courses; for maintaining the existing road communications either above or below the level of the rails; or for carrying the roadway above the surface of the ground in deep narrow gorges when for local reasons it is found that the construction of viaducts is preferable to the execution of heavy embankments. The choice of the materials used for the construction of railway bridges must mainly be influenced by economical considerations, always bearing in mind the fact that in *under*-bridges the materials used should be of a permanent description; because the repairs of the substratum, so to speak, of a roadway are always attended with difficulty; for *over* bridges wood, brick, stone, or iron may be used as may be found advisable. The reader is referred to the articles BRIDGE and VIADUCT for a detailed notice of the principles of construction required to be followed in this class of works, and under SKEW ARCH and TURNING BRIDGE will be found notices of peculiar forms of bridges frequently employed on railways. It seems that upon the average there are about 2¼ over or under road bridges per mile forward of railway in England, even when a considerable number of level crossings are allowed; in England there is at least one crossing per mile. As was before said, the latter should be avoided as much as possible, for they are a frequent source of accidents, and the cost of the guardian represents the interest of a larger sum than an ordinary bridge would cost. It is not often, in fact, that an ordinary over or under bridge costs more than 1000*l.* to 2000*l.*; or perhaps, taking into account the approach roads, the latter figure may be taken as an average; this has to be set against the cost of the cottage, gates, and crossing, and the keeper's wages, in case a level crossing should be resorted to. It is usual to estimate that the cost of culverts, surface, or underground drains of a railway amounts to 20 per cent. of the cost of the under-bridges; the cutting of the lateral ditches being carried to the earthworks account. The masonry for lining tunnels, or for retaining walls, forms part of those special items in railway estimates.

When the various works connected with the cuttings and embankments are finished, and the bridges are ready to receive the ballast, the railway is said to be brought to *formation level*, and all that remains to be done is to lay down the permanent way. The formation level is usually made about 2 feet below the intended rails level; the width of its surface is about 30 feet, exclusive of fences and ditches; and it is made higher in the centre than at the sides, in order to throw off the rain water.

Ballasting and laying the permanent way.—In the earlier periods of the history of railways very warm discussions were carried on with respect to the form of rail, and the mode of attaching it to the sleepers or blocks; but at present there seems to be a very marked tendency on the part of engineers to adopt uniformly the system of double-headed rails, keyed to chairs spiked upon cross wooden sleepers, and fish-jointed at the ends. As many useful lessons were learnt in the course of the experiments by which the system now generally adopted was arrived at, and the history of the superstructure of railways is in itself very interesting, a slight notice of the various phases of the discussions in question may be desirable. So much indeed of the commercial success of a railway depends upon the perfection of its permanent way, that it behoves every engineer, at least, to study carefully the phenomena which might have been observed during the respective trials; and it is even desirable that the directors of railway companies should know something of the previously made experiments in this matter so as to avoid a useless repetition of them hereafter.

When locomotive engines travelling at speeds of even nine miles an hour had been introduced, it was soon found that cast-iron fish-bellied rails were so liable to be displaced and fractured that their use was at once abandoned; parallel wrought-iron rails were substituted for them universally. On the Liverpool and Manchester, and on nearly all the railways executed by the Stephensons in the early periods of the railway system, the rails were keyed to chairs, fastened to stone blocks bedded in the ballast; but it was soon found that the blocks, which were isolated from one another, were exposed to sink unequally, and thus to deform the road; and moreover that the unyielding nature of the point of support (when it had once found a bearing) made the roadway very injurious to the carriages and rolling plant. Mr. Locke seems to have been the first to have adopted on a large scale (as the means of obviating these inconveniences) the use of the old system of wooden sleepers, passing beyond the two rails (as shown on *fig.* 10) so as to carry two chairs; and at the present day this system has been generally adopted wherever the rails are used with only occasional supports. Many essays of cast-iron sleepers have been made, without success, it must be added, for in the present state of iron metallurgy cast-iron goods are too brittle to be employed for articles subjected to the peculiar actions to which sleepers are forcedly exposed; but it is still to be hoped that means may be discovered by which this objection may be removed, and that this material, inattackable by insects and comparatively indestructible by atmospheric influences, may be substituted for wood. The rapid decay of the wooden sleepers has, indeed, been always the subject of anxiety to railway engineers; and many patents have been taken out for their preservation. Sleepers have been soaked in solutions of zinc, copper, mercury, &c., with variable success; but at the present day it seems to be generally admitted that creasote is the material which, when properly applied, contributes the most valuable properties to wood so exposed; all these processes are however but palliations of a serious evil inherent to the use of wood, and it certainly would be preferable to employ a material exempt from the conditions of decay above enumerated. However this be, the cast-iron chairs used either for blocks or for sleepers are spiked down with iron spikes, and some trifling modifications of the patterns of the chairs are at times advantageously made in order to avoid the splitting of the fibres of the wood. The rails are fastened to the chairs by means of compressed wooden wedges, which naturally expand again when exposed to the effects of moisture; these wedges are at the present day creasoted on the best lines of railway. Sleepers are usually from 7 to 9 feet long, by 10 in. by 5 in., and are usually placed at distances of 3 feet from centre to centre, on the average; especially on the lines where heavy locomotives are used.

Fig. 10.

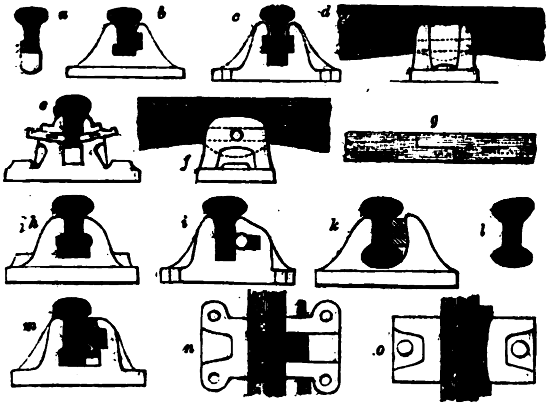


The sleepers, as was said, are laid in ballast, which should as far as possible consist of gravelly sand, sufficiently permeable by water to allow the rain to pass rapidly into the surface, and to the side drains. When, however, ballast of this description cannot be obtained, it may be replaced by sand, by shingle, by broken stones of not more than 2½ inches in diameter, by burnt clay, or by a mixture of chalk and flints; in mining districts forge ashes and broken slag are advantageously used. The ballast is made (for double roads) 30 feet wide and 18 inches thick, on the average; and its surface is dressed off so as to form a series of water-courses. It requires about 8,800 yards cube of ballast per mile forward of railways, or about 5 yards cube per yard lineal.

The form of rail used, and its weight, have passed through many changes, but they have finally resolved themselves into two principal varieties, known as the double-headed rail, and the bridge rail; the latter being employed on lines such as the Great Western, where continuous longitudinal bearings have been adopted instead of the ordinary chairs and sleepers. The advantages and disadvantages of the bridge rail will be discussed hereafter, and for the present, attention will simply be called to the steps which have led to the adoption of the double-headed rail most frequently employed.

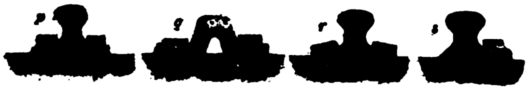
In figure 11, the illustration marked *a*, represents the section of the fish-bellied rail used on the Manchester and Liverpool line; *b* is the same rail fixed in its chair; *c* and *d* are representations of a rail of the same form used on the Newcastle and Carlisle railway; these rails were all fastened with iron keys. On the London and Birmingham railway Robert Stephenson introduced a modification of this system represented by *e* and *f*; this rail was partially replaced on the line of railway just mentioned by the form shown on *h*; and at *i* is shown a contrivance for keeping the rail in its seat. The double-headed rail may be considered to have been introduced by Mr. Locke, who used it on the Grand Junction and the South Western lines in the form shown at *k*; and eventually, notwithstanding the other modifications of the rail with intermediate supports as at *m*, Mr. Locke's form has been generally adopted. At *g*, *n*, and *o*, are represented the manners of forming the end joints of the rails, either with a half lap, or with butt ends, the system now prevalent; and at *l* is shown a rail of a peculiar section designed to fit more closely to the tires of the wheel. At the present day, however, little attention is paid to this theoretical perfection of the roadway, and the upper and lower surfaces of the rails are made identically the same. When firstly the double-headed rails were introduced they were made in 15 or 16 feet lengths, of about 56 lbs. weight per yard forward; at the present day they are made of from 70 to 80 lbs. per yard, and are often of 21 feet length. The cast-iron chairs have also been increased in weight, and instead of weighing for the joint chairs 20 lbs., and for the middle 15 lbs. each, they now weigh for the joint chairs 38 lbs., and for the middles 21¼ lbs. each. Latterly when the rails have been fish-jointed, or made with fish plates weighing about 28 lbs. per pair bolted on the respective sides of the rail, the middle chairs only are employed, and the sleepers at the end of each rail are brought as closely to the fish joint as possible.

Fig. 11.



When Mr. Brunel attempted to introduce the broad gauge he also attempted to introduce the American system of placing the rail with a continuous bearing, and thus was led to adopt the form of rails represented by *p*, *q*, *r*, and *s* on *fig.* 12, partly with the hope of being able to diminish the weight of iron. He began to use rails weighing about 45 to 47 lbs. per yard, and they were bolted or spoked to the longitudinal baulks at distances of about 18 inches; but the continually increasing weight of the locomotives, and the increased rate of travelling, have forced the parties who have used the bridge rail to follow the example of the advocates of the double-headed one; so that at the present day the bridge rails are often made of even 90 lbs. weight per yard forward. The great objection to their use lies, however, in the necessity they involve for a very expensive timber substructure, which is liable to rapid decay, and to frequent deformations by the warping of the wood, or by the expansion of the rails. Practically, then, although the system of continuous bearings produces a road of a very pleasant description for the traveller, so long at least as it is in order, it is found to be of so costly a maintenance that it is rarely used in England, unless when the roadway has to be carried over viaducts, bridges, or other works, where the percussion upon the intermediate bearings might become injurious.

Fig. 12.



It may be as well here to observe, that in laying rails, the allowance for the elongation produced by summer heat must be very carefully made. In a 15 feet rail, the difference of length for an increase of 76° Fahr. will be about $\frac{1}{11}$th of an inch; but at the same time that provision must be made for the free expansion of the rails, they must not be laid with so open a joint as to give rise to concussions. It is usual, also, to give a slight inclination to the upper surface of the rails, inclining inward about 1 in 30, for the purpose of giving a better bearing to the conical surfaces of the wheels; and in curves, the outer rail is elevated above the inner one, by a height regulated by the maximum velocity attained upon the curve, and by its radius. Upon level crossings, very sharp curves, viaducts, or bridges, it is usual to fasten counter-rails; but they have so often proved sources of danger, through their independent movements, that these counter-rails are never placed unless under very exceptional circumstances. On level crossings they are necessary in order to protect the rails from the shocks of passing waggons. A very common elevation of the outer rails, on curves of 1000 yards radius (and this seems to be the minimum radius which should be allowed in railways upon which ordinary express speeds are attained) is about 2 inches; and in curves near stations, of 500 yards radius, the elevation becomes about 2½ inches. Fractures of the rails occur on changes of temperature, and chairs are frequently broken when wedged up too tightly. Great care is therefore required in the inspection of the rails at these seasons; and it is worthy of remark, that there is a marked tendency of the rails to displace themselves in the direction of the movement of the trains, especially on inclines and near the stations. In some cases, every 10th or 20th rail is notched upon its chairs, in order to resist the tendency to this kind of displacement.

The battle of the gauges, which raged so furiously a few years since, has now been practically solved by the adoption of the mixed gauge on the Great Western line itself; and indeed the advantages of a uniformity of gauge are so much greater than those which can be secured even by a more logical arrangement than the one adopted originally by Mr. Stephenson, that it is almost idle to discuss the question at present. For all useful purposes, it is ascertained that the 4 feet 8½ inches gauge is as efficient as the 6 or 7 feet gauge; and it is immeasurably cheaper, both as regards the formation of the roadway and the construction of the rolling plant. It seems that the precise gauge of 4 feet 8½ inches was the result of a mere accident; but as it has been adopted on the majority of railways, it is now desirable to carry it out on all similar works. The space between the rails is usually made 6 feet from edge to edge.

Accessories of the Roadway.—It is often necessary to pass engines and carriages from one line of rails to another, and this is effected by means of switches or points, and crossings by turn-tables, or by traversing platforms. If we suppose, as in *fig.* 13, a series of cases in which such changes of direction may be necessary, we may perceive that some contrivance is required to guide the flanges of the wheels in such wise as to cause them to follow the new line of rail they are intended to travel upon. This contrivance consists of two moveable rails (*fig.* 14) working simultaneously and parallelly upon fixed pivots, so that the flange of the wheel on one side should bear against one of the rails, and should thus be forced to follow it, whilst the other flange would find an open passage which would allow it to follow the new line of direction given. Many varieties of points and crossings have been introduced from time to time, of which the most concise account is to be found in Perdonnet's 'Traité Elémentaire'; but for our present purposes it may suffice to say that the system now generally adopted is the one known by the name of Wyld's patent, in which the surfaces of the rails in the principal line are not touched, but the tongues of the points are made to pass gradually under the heads of the main rails. On the Great Western line many of the points were originally made as in *fig.* 15. The radius of the curves of the best points and crossings is usually made equal to 1650 feet, and care is taken that counterpoises should be fixed, to keep the main line open; as far as possible, also, no points should be fixed so as to meet the advancing trains on the main line. At the points of turns out of single lines of railways, and at the junction points of embranchments, signal posts are invariably fixed for the purpose of indicating which line is open, and the radius of curvature is made as large as possible. On the Belgian lines, the embranchments are made near the stations, and sometimes the radius of the points does not exceed 1000 feet; but it is to be observed that these embranchments have no back curves like those of ordinary crossings. It may be as well to add, that where the two rails cross one another, grooves are cut to allow the flanges to pass, and guard-rails are placed to check any tendency of the rails to leave the road, as shown in *fig.* 13.

Fig. 13.

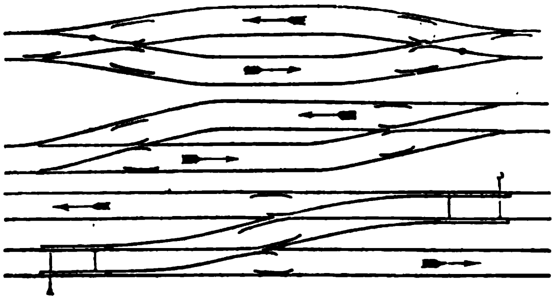


Fig. 14.

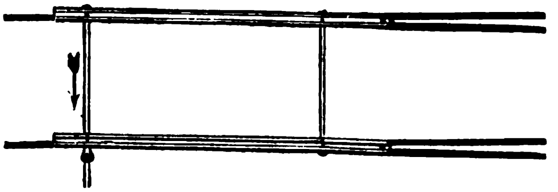
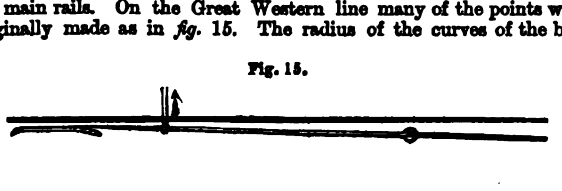
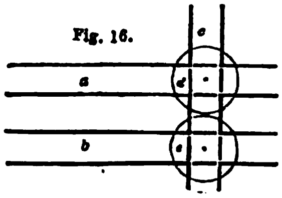


Fig. 15.



Turn-tables present a marked advantage over points and crossings in this respect, that they allow the carriages, &c., to pass from one line to the other in a much smaller space; but the operation itself is performed slowly, and must be repeated for every separate carriage. Turn-tables consist of circular platforms of wood and iron, fixed on a level with the rails, and mounted on friction-rollers, so as to turn freely upon their central pivots; four rails are fastened on the upper face, and made to correspond with the positions of the longitudinal and transverse rails at each quarter revolution, in such cases as those represented in *fig.* 16, wherein, if it were desired to transfer a carriage from the line a to the line b, the carriage would be rolled to d; a quarter revolution of the table is then made, and the carriage is pushed on to e; a similar quarter revolution of the table e is made, and the carriage could then be advanced in either direction on the line d. The dimensions of turn-tables depend on the sizes of the carriages to be moved: thus, for goods waggons, an 8-feet table will suffice; for passenger carriages a 12-feet table is necessary; whilst for locomotives and tenders coupled together, tables of as much as 36 or even 50 feet diameter have been made. Sometimes the turn-tables of stations are made to serve a series of converging rails; and in the engine-houses of some railways a large table is placed in the centre, so as to serve the purposes of as many as 16 lines.

Fig. 16.



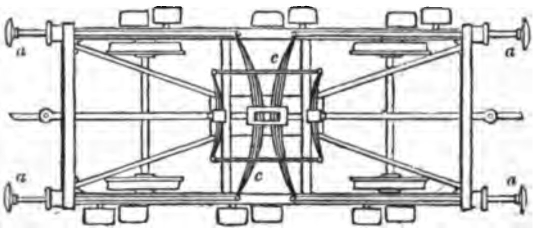
Traversing platforms are used when it is desired simply to pass engines or carriages from one line of rails to another situated parallelly to it. They are exclusively fixed in stations where no through traffic can possibly be admitted; because they consist of a platform susceptible of movement only in a direction transversal to that of the line of rails, and moving on rollers in a deep pit extending the whole length of the lines thus put in communication with one another.

Water-tanks, water-cranes, pumping-engines, and wells, constitute useful adjuncts of railways, but they hardly require special notice in this article. The signal posts, for both day and night services; the provisions for the establishment of the electric telegraph; the watch-boxes even for the guardians of the way in particular positions, must also occupy the serious attention of the railway engineer. Local circumstances must, however, so modify the manner of dealing with all these questions of detail, that it would be dangerous to attempt to lay down any absolute principles with respect to them, otherwise than by saying that every convenience should be provided to facilitate the discharge of duties upon which the safety of the public so materially depends. It may be added that, with respect to the service of the water-columns for the supply of tenders, the tendency of modern practice is to make them with reservoirs able to hold about 200 cubic feet of water, and to place those reservoirs immediately over the delivery-pipe, so as to ensure the rapid filling of the tenders; the reservoirs are themselves filled during the intervals of the trains. Heating apparatus are also provided for the water-columns, in order to prevent the freezing of the water. Good signals are especially required at the entrances of long tunnels, and at the points of the turn-outs of single lines of railway, or at embranchments.

On some lines, or portions of lines, as on the old Birmingham and the Blackwall Railways, upon the goods lines at Liverpool, and upon the line from Liège to the Prussian frontiers, it was thought advisable to substitute fixed machinery for the locomotives employed on the other parts of the line. These machines, in fact, gave motion to endless ropes, passing over grooved wheels and running from station to station upon friction-rollers, to which ropes the carriages were attached, and were thus hauled along. In almost every case, but those at Liège and at Liverpool, these engines have been abandoned; and indeed, the improvements lately introduced in the details of locomotive engines have rendered their intervention unnecessary; and it may be suspected that at Liège, even the fixed engines would have been abandoned, had they not been placed on a line in the direct control of the state. The same description of remark may also be extended to the atmospheric railway, which has been so universally abandoned by engineers, that it may suffice here to refer those who desire to make themselves acquainted with its practical and theoretical defects, to the late Mr. R. Stephenson's report upon the subject. The system thus referred to was tried on the largest scale, both in England and in France; and in both countries it has signally failed (when compared, economically) with locomotive traction. [ATMOSPHERIC RAILWAY.]

Rolling Stock.—Railway carriages for the conveyance of passengers are usually very capacious, the bodies being made to project over the wheels, which in ordinary lines are made 3 feet, or 3 feet 6 inches in diameter; but as the centre of gravity of the carriages is kept very low, the oversailing of the frame produces no evil effects. On account of the rapid speed at which the carriages travel, and the violent shocks to which they are occasionally exposed, their frames are necessarily made of great strength; and every precaution is taken by the introduction of springs and buffers to diminish the violence of the blows they receive, or the effect they themselves might produce upon the rails. Elasticity in the traction is also necessary as well for the safety and comfort of the passengers, as for the preservation of the carriages; and even in order to economise engine power, for if it did not exist, the engine would be obliged to exercise a greater power to start the trains than it would do for the maintenance of the speed once attained. Various contrivances, more or less successful, have been adopted to secure these conditions; but the system represented in *Fig.* 17, is the one usually adopted; it represents the plan of the framework of a carriage, the body being supposed to be removed. The frame is carried on springs fixed outside the wheels, and resting on brass bushes, which bear directly on the axles: *a*, *a*, *a*, *a*, are the buffers, or discs of wood or metal, covered with cushions, and fixed to the ends of metal rods, working between guides against the ends of very strong horizontal springs *c*, *c*. In such cases, when the train is suddenly stopped, the springs are forced against one another, and serve thus to soften the blow to an extent dependent upon the force of the spring. The draw-bars are also attached to the centre of the horizontal springs, and thus prevent any sudden jar to the frames of the carriages at their starting, and the several draw-bars of a train are attached to one another by a coupling chain, bearing a double thread, so as to force the buffers into close contact; loose chains are also placed by the sides of the buffers, in case the coupling chains should break. Many varieties of springs have been applied for both the purposes described above; but experience has led engineers to resort to the old-fashioned plate springs, of course of considerable thickness, and of the very best quality of steel. The ordinary first-class carriages have three compartments, able to contain from six to eight passengers in each compartment; the second-class carriages mostly have three or four compartments with ten passengers in each compartment; whilst the third-class carriages are made to contain from fifty to sixty passengers each. The weight of the best modern first-class carriages, on the narrow-gauge, is about 5¼ tons; that of the second-class is about 6¼ tons; and that of the third-class 6 tons: or, in other words, the ratios of the dead weights of the carriages to the loads transported are, in the several classes, as 2·9 to 1; as 2·1 to 1; and as 1·6 to 1. A certain number of the carriages in each train is made with breaks, and a guard's van, with occasionally an extra luggage van, are added. Horse-boxes, carriage-trucks, and post-office waggons are made upon the same principles of framing and suspension, as the ordinary traveller's carriages, so as to allow of their being added to the same trains as the latter. As the goods waggons do not travel at the same velocity as the waggons for the conveyance of passengers, there is not the same attention paid either to their modes of suspension, or to their draw-bars; but every waggon which is added to a train moved by a locomotive engine is hung upon springs, even when there is no spring draw-bar; there is very rarely any buffing apparatus attached to merchandise waggons. On ordinary narrow-gauge lines the weights of goods carriages range between 3 and 5 tons; they carry about 5 tons each.

Fig. 17.



As there is now almost a certainty that the broad gauge will be abandoned, it is only necessary to observe that upon that system the carriages are not only more expensive, but that the ratio of the dead to the useful weight is even more unfavourable than the one which prevails upon the narrow gauge lines. It may also here be added that upon almost all the continental lines of railway the carriages are much more commodious than they are upon the English lines; and that in America only two classes of carriages are admitted, one for the white passengers, the other for merchandise and negroes. The American carriages usually run on eight wheels, coupled by what are called bogie frames in two pairs, in order to diminish the length of the tangential line formed by the fixed axles with the curves of the roadway they travel over; the wheels, however, are very small.

We have already seen that, during the gradual development of the railway system, there has been a constant tendency on the part of machine-makers to increase the power and the weight of the locomotive engine, until it has at last attained the colossal dimensions before stated. Originally also the locomotives were made with only four wheels; but the frightful accident on the Versailles line in 1842 raised so strong a prejudice against engines of that class, that they have been universally abandoned. Six-wheeled engines are now the only ones used on our English railways; sometimes with the tenders attached to the engine, and upon the same frame; and sometimes with the tenders entirely detached, and carried upon a distinct set of four wheels, as is the case with any ordinary carriage. In America, and on the lines in Germany with very steep gradients, the engines are made with eight, or even with ten wheels; the tenders being, in either of those cases, upon the same frame as the engines, but the wheels working upon two bogie axle frames. In ordinary passenger engines the cylinders are placed internally, and the piston-head communicates motion directly to the crank upon the large centre wheels, which thus become the driving-wheels, leaving the fore and hind pairs of wheels simply to act as trailers. *Figs.* 18 and 19 will convey a tolerably correct notion of the engines thus referred to; and in them *a* represents the fire-box, usually made of copper, and surrounded by an outer casing of iron, so as to leave a space all round surrounded by water; *b* represents the boiler, with its horizontal tubes of about 140 or 150 in number, and made of brass, passing from the fire-box to the smoke-chamber, *c*; *d* represents the steam-chest, which in modern engines is made considerably smaller in proportion than it used to be. The steam passes through the smoke-box to the cylinders at *e*, and there is upon the tube which so conveys it a throttle valve, under the control of the driver; *f* and *g* represent the safety valves, and *i* the feed-pipes from the engine to the tender; *h* represents the steam-whistle. Until very lately all locomotive engines were heated with coke, but a notable economy has been obtained on some lines by the substitution of coal for coke, by means of some alterations in the fire-boxes and the grates. The escape-steam in all locomotives passes off through the chimney above the smoke-box. On some lines of railway the cylinders, instead of being placed inside the frame, are placed externally to it, so that the motion is communicated at once from the piston through the crank to the driving axle, without the necessity for forging a crank on the axle itself; but there seems to exist a great disinclination on the part of the majority of engine builders to adopt this simple arrangement, perhaps on account of the condensation which takes place in the cylinders, and on account of the frequent ruptures of the cylinders which occur in these engines. The driving-wheels of ordinary express locomotives, on Crampton's system, are now made 8 feet in diameter; the cylinders about 18 inches diameter, and 2 feet stroke; the heating surface in the fire-boxes is about 154 feet superficial, and the heating surface of the tubes about 2200 feet; the pressure of the steam is often 120 pounds on the square inch. Such an engine, with its tender filled with coke and water, would, at a maximum, weigh 36 tons; the trailing or carrying-wheels are 3 feet 6 inches in diameter.

Fig. 18.

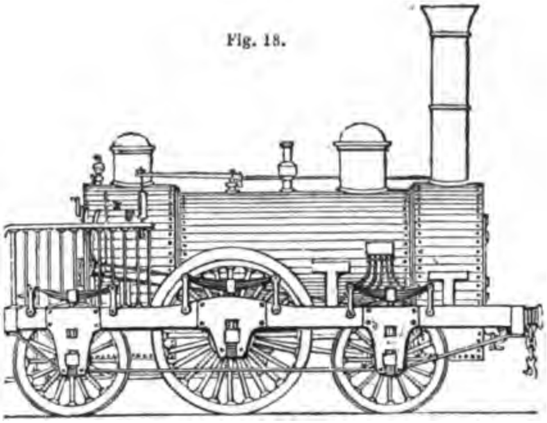
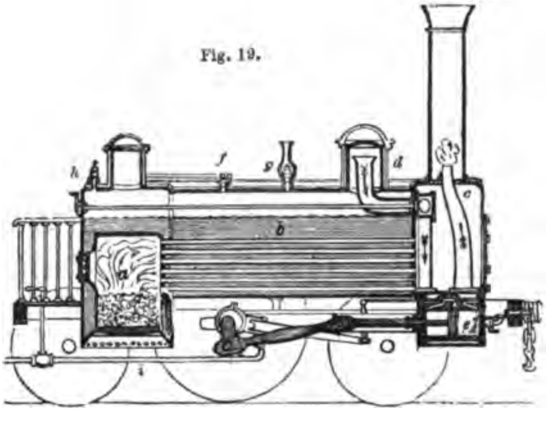


Fig. 19.



The goods engines are usually made with four driving-wheels coupled, of from 4 feet 6 inches to 5 feet in diameter, and two carrying-wheels, for the narrow-gauge lines, at least, where the inclines do not exceed 1 in 100. On the line across the Sœmering, however, there are four driving-wheels coupled, and mounted on one bogie frame, and six carrying-wheels mounted on another. The object aimed at in these cases is to increase, as far as possible, the adhesion on the rails; and to secure the greatest possible length of boiler, and the greatest heating surface. The weight of an ordinary goods train may be considered to be about 150 to 250 tons; that of an ordinary passenger train about 80 to 100 tons.

Stations.—A very important part of the establishment of a railway consists in the erection of the intermediate and the end stations. The result of past experience seems to prove that it is by no means advisable to construct these buildings, at the first opening of a line, in a costly or a permanent manner; but rather that the true policy of a railway company is to purchase at once all the land that may be required, and only to erect the permanent buildings when the traffic has had time to develope itself. As a general rule, it would seem to be necessary to purchase an additional quantity of ground, beyond that which is required for the roadway, of about eight acres for a first-class intermediate station; and of about four acres for a second-class one; the terminal passenger station for a first-class railway will require an area of about 4 to 6 acres; whilst the goods station of such a line will require about 25 or 40 acres, and the repairing shops, carriage depôts, engine houses, coke ovens, may require at least 12 acres. It may be added that in a large passenger station at a terminus, as many as forty people are constantly employed; and in a large terminal goods station there are often as many as 140; on a first-class intermediate station there are usually about ten people employed, and on a second-class station only about four. It has been found that the average length of sidings for turn-outs and goods stations, on lines with a large traffic, is not less than from 12 to 15 per cent. of the whole length of the through way; and the expense of the station buildings has been found to be not less than 2000*l.* per mile lineal of the distance between the termini, when no very costly or monumental buildings have been attempted. In all cases the embarcation and landing of passengers should be effected under cover, and the same remark of course would apply to goods; the passenger platforms should be finished at the level of the floors of the carriages.

Cost.—Finally, it may be desirable to state that in England the average cost of all the railways already executed has exceeded 33,000*l.* per mile; but that there is little reason for calculating the cost of the railways which may have to be made hereafter at more than 16,000*l.* per mile, unless there should be an abnormal proportion of the line carried through town property. The rolling stock will be found to have cost from 2000*l.* to 3500*l.* per mile of railway; and of the portion of the capital specially devoted to the construction of the roadway, in double lines of road, the earthworks will cost about 40 per cent.; the permanent way 40 per cent.; bridges, &c., 12 per cent.; and land 8 per cent. Of course, however, these figures must only be regarded as rough average approximations. Every line of railway presents its own peculiar difficulties and special causes of expenditure. Thus it has arisen that the average cost of the railways in England has borne to those of other countries so very remarkable a proportion. With us they have cost nearly one-third more than in France; twice as much as in Belgium; two and a half times as much as in Germany; and about five times as much as in the United States of America.

Statistics of Railways.—It is difficult to collect any very trustworthy statistics of the precise state, at any particular moment, of a class of operations so essentially exposed to change as railways must be. The following table must therefore only be considered to represent the real state of the case in a very rude and approximate manner. Every month witnesses the opening of a new line of railway; every year witnesses the adoption of the railway system in a new country.

In the year 1856 it was calculated that railways had been commenced in Europe of the lengths subjoined. The population of the different countries is added. About three-fifths of the length then undertaken had been completed.

Countries.	Population.	Miles of Railway.
Great Britain	27,323,000	12,801
France	35,547,000	7142
Germany, small states	16,804,000	2827
Austria	38,400,000	2701
Prussia	16,200,000	2557
Belgium	4,524,000	1118
Denmark	2,132,000	118
Spain	14,216,000	1330
Holland	3,243,600	208
Italy	17,000,000	1315
Russia	63,600,000	29

In Mr. Fenn's book, 'On the Funds,' he quotes (p. 400) from Mr. Danvers a table of perhaps greater interest than the one given above, insomuch as it contains much information as to the cost of some of the railways, and as to their commercial results, not only in Europe, but in other quarters of the globe.

Name of State.	Year.	Length of Line open.	Total Capital expended per mile of Line open.	Receipts from Traffic per mile of Line open.	Net Receipts per mile of Line open.	Proportion per cent. of Working Expenses to Receipts.	Proportion per cent. which Net Receipts bear to Capital expended.
		Miles.	£	£	£		
Austria	1856	1586	16,378	2190	1040	52·70	6·32
Belgium	1856	445	16,391	2158	898	58·16	5·48
France	1854	2913	25,668	2706	1515	44·01	6·58
Germany, exclusive of Austria and Prussia	1855	2226	13,111	1816	919	49·28	5·70
Great Britain:							
England and Wales	1857	6706	39,275	3161	1597	48·00	4·06
Scotland		1248	26,225	2107	1166	44·00	4·13
Ireland		1070	15,664	1091	626	38·00	3·99
Holland	1857	163	19,931	1709	667	60·96	3·35
Prussia	1856	2503	14,101	1877	909	51·59	6·22
Sardinia	1855	234	..	1477	703	51·33	..
Spain	1856	120	..	924	402	56·48	..
Switzerland	1856	203	19,888	636	295	54·28	1·48
Tuscany	1856	132	15,556	966	520	46·18	3·34
United States of America	1855	17,481	8,275	1234	568	54·00	6·78
East Indian	1858–59	142	12,084	1447	770	45·04	7. 4. 10
Great Indian Peninsula	1858–59	194	8,758	784	437	44·1	5. 14.
Madras	1858–59	96	7,000	499	234	52·9	3. 1. 6

In addition to these figures, it may be as well to state that, according to the Report on the Railways of Great Britain, issued by the Department of Railways in 1859, the total number of miles open for traffic was,

			£	s.	d.
In England and Wales	7217 miles;	the receipts	9,989,959	17	6
In Scotland	1369	" "	1,267,792	3	9
In Ireland	1210	" "	604,987	9	8
Totals	9796		£11,862,739	10	11

The total sum raised and expended on these lines to the end of December, 1859, was not less than 335,435,071*l.*

The returns given by Mr. Consul Ward of Leipsic show that in Germany Proper, in 1858, there were open for traffic 7360 miles of railway, which had cost about 120,000,000*l.*; and in addition thereto about 501 miles of railway had been opened in Hungary and Gallicia. The length of railway opened in the United States was, at the end of 1859, not less than 27,857 miles; they had been constructed at a cost of 192,209,473*l.*, and they yielded a total revenue of 9,681,500*l.* nearly. In Canada there were 2061 miles of railway opened up to the same period; and, in our East Indian colonies, 665 miles; whilst in the Cape colony, Ceylon, New Brunswick, Nova Scotia, Demerara, Jamaica, Australia; in the Brazils and the central American States, and in Cuba, numerous lines were opened, and in progress. The great company which is at work upon the main lines of Russia has undertaken to complete in ten years about 4162 miles of railroad; whilst in Asia Minor and in Egypt there are short lengths already open to traffic. In a very few years, indeed, railroads will be found in every civilised country, perhaps even to the exclusion of every other description of road; for in proportion to the value attached to time in commercial affairs will this rapid means of intercommunication become more and more necessary. The rates at which goods trains now move are between 17 and 20 miles an hour; the passenger stopping trains travel at rates of between 27 and 30 miles, and the express trains at rates of between 37 and 45 miles per hour. In these days, when time is emphatically money, no nation, which desires to maintain its position in the world, can dispense with a system which enables it to travel under the same conditions of speed as its neighbours, notwithstanding that the cost may be considerably greater in one case than in another. The Dutch government at last has felt this truth, and even it has been induced to commence a series of railways which will involve an outlay of at least 10,000,000*l.* sterling.

RAIN. The ancients appear to have been very imperfectly acquainted with the constitution of the atmosphere; and Descartes was probably the first who, in attempting to refer meteorological phenomena to their causes, approached near the hypotheses now generally received; for he ascribes the formation of clouds, snow, rain, and hail to variations of temperature in the upper regions of the air. He supposes that when the coldness of any portion of those regions becomes intense, the subtle matter disseminated among the particles of vapour becoming too weak to keep those particles at a distance from one another, the latter must rush together, and either form small spicular filaments or spherical drops of ice. The superficies of these filaments or drops being supposed to be considerable when compared with their volumes, he conceives that the resistance of the air may be great enough to prevent them from descending by their weight, and that thus a great assemblage of them may remain suspended in the form of a cloud above the earth. The filaments becoming by an accession of heat partially liquefied, it may happen that many of them will adhere together, and thus form flakes of snow, which, at length acquiring sufficient weight to overcome the resistance of the air, descend to the ground. In order to explain the origin of rain and hail, he supposes that the flakes, on arriving near the surface of the earth, may pass through a warmer region than that in which they were formed, and there dissolving, they assume the figure of spherical or spheroidal drops of water. Again, if in the descent the latter should meet a current of cold air, they become globules of ice. ('Meteora,' cap. v. vi.) The absence of observation in all this, however, is evinced by the theory of the formation of snow, to which it is evident that Descartes never applied even such a moderate magnifier as he might readily have obtained, or he could not have failed to see the true nature of its aggregation.

The diffusion of electricity through the earth and atmosphere has led some meteorologists to believe that the variations in its quantity or intensity in particular regions may be the cause of the formation of snow, rain, and hail. The electrical particles, being endowed with a great repulsive power, are supposed to keep in general the particles of vapour asunder; and when, from any cause, some given volume of air is deprived of its natural quantity of electricity, these particles unite by their mutual attractions, and thus form drops of rain or ice. From the showers which accompany a thunder-storm, there is no doubt that electricity co-operates in some measure in the production of rain; and it may be remarked in support of the above hypothesis that rain is most abundant among mountains, their elevated summits being favourable for receiving and discharging electricity; while in some regions where thunder is little known there is also little rain. But the idea that repulsive electrical particles keep asunder the particles of aqueous vapour is itself purely hypothetical.

The theory first proposed by Dr. Hutton of Edinburgh ('Trans. Roy. Soc. Edin.,' 1784), is that which appears to correspond most satisfactorily to the observed phenomena of the atmosphere; and accordingly it has been adopted by nearly every distinguished meteorologist since that time. This theory will be briefly described.

The atmosphere surrounding the earth is known to consist of air and aqueous gas or vapour, both of which are elastic; and, according to the experiments of M. Gay-Lussac, the elasticity of the vapour is equal to that of the air at an equal temperature, both when the vapour exists alone, and when it is diffused through the air; hence it is inferred that in the atmosphere the vapour and air are in mechanical mixture only, and also that the particles of the former have the power of moving freely in the intervals between those of the latter. The atmosphere is supplied with humidity by evaporation from the waters of the earth, and its power to hold the water in suspension depends on its temperature, an increase of the latter augmenting that power, and a decrease diminishing it: but in the theory of Hutton, the diminution of the power takes place in a higher ratio than the diminution of the temperature.

Now the quantity of moisture in the atmosphere will at all times be nearly equal to the greatest quantity that can be maintained in it in a state of vapour at the existing temperature. Therefore if two volumes of air thus saturated with moisture, but of different temperatures, become by any means mixed together, a mean degree of heat results from the union; but the whole quantity of moisture in the sum of the volumes of air will, agreeably to the theory, be greater than that which is due to the mean temperature, and the excess will of course be condensed or precipitated. The vapour so condensed forms a cloud [CLOUD]; and if this be specifically heavier than the air in which it is formed, it will begin to sink: the internal friction of the air, as Professor Stokes has recently shown, will for a time retard its descent, allowing it to remain suspended until the resistance from this cause is overcome by the increasing magnitude of the drops. Should the atmosphere near the earth be less dense than the cloud, the latter will continue to descend till it touches the ground, when the aqueous particles, if small, will form what is called a mist; or if large, and particularly if the condensation of the vapour has been rapid and copious, they will descend by their gravity in rain, snow, or hail, according to the temperature of the region in which they have been formed or through which they pass. It may happen, however, in the descent that a cloud arrives in a warmer region than that in which it was formed; in this case the condensed moisture may again become vapour, which may re-ascend to a region at which a new condensation takes place. But though it be true that some precipitation must follow, whatever be the difference between the temperatures of the two volumes of air, yet unless the mean of the two quantities of vapour should be greater than the quantity necessary for complete saturation at the mean of the two temperatures, the precipitation will not be perceptible in the form of rain.

In order to illustrate the general subject of clouds and rain, the late Professor Daniell, in his 'Essays on the Constitution of the Atmosphere' and 'Meteorology,' supposes, first, that the earth is a sphere of uniform temperature, and surrounded by an atmosphere of dry and permanently elastic fluid; and he shows that on this supposition the density of the air would diminish in a geometrical progression at elevations increasing by equal increments. He observes also that the temperature would decrease with the densities, and that the atmosphere would be constantly in equilibrio. This would continue to be the case if the general temperature of the sphere were to be increased, provided that increase were uniform at all points on its surface. Now, if the temperature of the sphere, instead of being uniform, were supposed to increase from the poles towards the equator, the unequal densities produced in vertical columns of the air by the differences of temperature at equal heights above the surface of the sphere, would give rise to lateral pressures which, in the lower strata, would produce currents tending from the poles towards the equator; but the elasticity of the air, which is constant near the surface of the sphere, varies with the height above that surface, according to such a law that, beyond a certain elevation, it would produce lateral pressures exceeding those which arise from the density in the neighbouring columns at equal altitudes, and thus there would arise a current in the upper regions flowing continually from the equator towards the poles.

He supposes next that the sphere is covered everywhere with water of equal temperature, and is surrounded by an atmosphere of pure aqueous vapour; and he shows not only that the density of this vapour would diminish upwards, according to the law before mentioned, but that the atmosphere would in this case also be in equilibrio and transparent even when the general temperature of the sphere experiences a uniform increase. But if the temperature of the sphere were to increase as before, from the poles towards the equator, the density and elasticity of the vapour varying also with the temperature, there would arise by evaporation at the equator a current tending from thence to the poles, and this, being condensed in its course, would return from the poles towards the equator in the form of water. The condensation thus going on would cause the atmosphere to be constantly charged with clouds and rain. Unless, however, the excess of temperature at the equator were maintained by some foreign power, as solar radiation, the temperature over the whole sphere would by degrees become equalised; the equatorial parts becoming cooled by evaporation, while the polar regions would become warmed by the condensation.

Mr. Daniell afterwards contemplates an atmosphere consisting of a permanently elastic fluid mixed with aqueous vapour, and surrounding a sphere of water of uniform temperature; and he observes that, since the evaporation would be slow, the small quantity of water precipitated would be almost immediately dissolved by the superior temperature of the stratum below, into which it would tend to fall; therefore this atmosphere would be free from clouds. But in the event of the temperature of the sphere increasing from the poles to the equator, the evaporation in the latter region would destroy the regular gradation of temperature in the atmosphere from the surface of the sphere upwards; the evaporated water rising to the middle regions would there, in consequence of the diminished temperature, give out its latent heat, and become condensed; then descending, it would acquire from below a new portion of heat, with which it would rise till it was again forced to part with its caloric. This process may be supposed to continue till those regions of the atmosphere become saturated with vapour, and at the same time rarefied by the heat. The rarefaction of the air would diminish its resistance to the general movement of the vapour towards the poles, and thus the vapour would rush with force in those directions; but on arriving in latitudes at which the temperature is too low to allow the air to hold it in solution, condensation would take place, and clouds would be formed.

The circumstances just mentioned correspond nearly to those which would take place about the earth if local and other accidental circumstances did not interfere with the general process. In its actual condition, when a column of air vertically over any place is from any cause heated more than the neighbouring columns, it begins to ascend by its diminished specific gravity, the colder air of the vicinity flows in to fill up the void, and thus the relation between the temperature and humidity at the place is deranged. Then, agreeably to the general theory of Dr. Hutton, a precipitation of the vapour takes place.

In proportion to the density of the vapour, the magnitudes of the condensed particles of water are greater (this, however, does not appear to be proved, and the magnitude of the particles must be in some ratio to the temperature of condensation); in the upper regions of the air the cloud assumes a light appearance, but below it is more dense. After their formation, the clouds are driven about by the winds, receiving new accessions of precipitated vapour till the air is no longer capable of supporting them, and then their substance descends in rain, snow, or hail.

On the supposition that the surface of the earth is without inequalities, and that the temperature gradually diminishes from the equator towards either pole, it should follow that the rarefaction of the air and the evaporation of the water, and consequently the quantity of rain, must diminish according to some law with the distances of places from the equator. Now the mean temperature in any latitude being known, the quantity of moisture in the atmospherical column at that latitude can be found, since it depends on the temperature: hence, knowing also the variations to which the temperature of the atmosphere at the place is subject in the course of the year, the mean annual depth of rain in that latitude may be computed. On such principles, Humboldt determined that the mean annual depth of rain should be, at the equator, 96 inches; in lat. 45°, 29 inches; and in lat. 60°, 17 inches. The circumstances, however, which render the temperatures in different latitudes, and even on the circumference of the same parallel, irregular, must produce irregularities in the quantities of rain which fall at different places; yet the results of observation show that, in proceeding from the equator towards the north pole, there is in reality a diminution in the mean annual quantities of rain.

From an average of the observations made during fourteen years (1810 to 1823 inclusive), the mean annual depth of rain on the Malabar coast is 123·5 inches, and the mean annual temperature is 80·4° (Fahr.), but the annual depths of rain are very irregular, and differ considerably. From a mean of observations for seven years (1817 to 1823 inclusive), the mean annual depth of rain at Bombay was only 85·24 inches. From a mean of observations during seventeen years (1802 to 1818 inclusive), Mr. Dalton makes the mean annual depth of rain at Manchester equal to 33·596 inches, the mean annual temperature being 47·6°; and here also the annual quantities of rain vary very irregularly. The same meteorologist estimates the average of the annual quantity of rain in England to be 31·3 inches; the greatest quantity, according to the data he investigated, being at Keswick in Cumberland (=67·5 inches), and the least at Upminster in Essex (=19·5); but it is supposed that this estimate of the mean quantity is higher than the truth, because too many of the observations were made in the maritime counties, where the atmosphere may be expected to be the most humid. According to observations made by members of the British Meteorological Society, collected and discussed by Mr. Glaisher, the quantity of rain that falls annually in the islands of Jersey and Guernsey is about 31 inches; in the counties of Cornwall and Devon from 30 to 40 inches, or in some places still more; in the Isle of Wight and over the south of England about 30 inches; about London 25 inches; about the town of Bedford and the cities of York and Durham 24 inches; near the east coast 27 inches; 30 inches near the west coast; and about 27 or 28 inches elsewhere.

The late J. F. Miller, F.R.S., of the Observatory, Whitehaven, Cumberland, by whom the meteorological phenomena of the English lake district were accurately observed and recorded, ('Phil. Trans.,' 1851, &c.) showed that in the valleys of Cumberland and Westmoreland, the usual fall of rain varies from 50 to 100 inches in depth in a year; and these large quantities increase with the elevation, till the greatest annual depth of rain is attained at the altitude of about 1000 feet; at higher elevations it decreases in amount. He records the very large fall of 38·9 inches in a single month, a quantity exceeding the average annual fall of all England. The hamlet of Seathwaite, in Borrowdale, was until lately considered to be the wettest spot in Great Britain, the rain-fall, in the year 1850, amounting to 143·96 inches. But Mr. Miller ascertained that this was greatly exceeded by a new station for observation about a mile and a-half south-west of Seathwaite, and 580 feet above it, or 980 feet above the sea-level, at the extreme southern termination of the valley, on the shoulder of Sprinkling Fell, or the Stye. In 1850 the rain-fall at this station amounted to 189·49 inches.

In regions where the trade-winds blow constantly rain seldom falls, and the reason may be, that both the temperature and the currents of air being there nearly uniform, the vapours raised from the ocean are carried about the earth without suffering those partial accumulations by which condensation and precipitation might be produced. But elsewhere the irregular distribution of land and water, the existence of mountain-chains, and even the various capacities of different parts of the earth's surface for absorbing or communicating heat, independently of variations in the electricity of the air, are to be considered as the most frequent causes of perturbation in the general currents of the atmosphere, and consequently of the fall of rain.

The dense mists which rest on the ocean near Newfoundland are precipitations caused by inequalities in the temperature of the ocean in the line of the *Gulf-stream*. In the year 1821, in consequence of very strong winds between the tropics during the summer having caused an extraordinary difference between the levels of the waters in the Gulf of Mexico and those of the Atlantic Ocean, the stream of warm water was found to extend eastward of the Azores; and it deserves to be remarked that this unusual circumstance was attended, both in France and in England, by a very hot and damp winter, together with an excessive fall of rain. (Sabine, 'Experiments on the Figure of the Earth,' 1825.) The rains which frequently deluge the tropical islands are in part produced by the volumes of air which are intermingled by the sea and land breezes; and those which fall at the time of the summer solstice in Africa may be ascribed to the immediate precipitation of the vapours which flow from the seas to supply the place of the rarefied air above the heated lands; while the drought which prevails in the sandy deserts of that quarter of the earth is partly explained by the level character of those deserts, over which the currents of air may be supposed to flow nearly without interruption.

From April to October, the winds blowing from the south-west towards the coast of Malabar are accompanied by heavy rains, and the circumstance may be accounted for by the vapours of the ocean being brought from a warm region to one which is less so, and consequently becoming there condensed and precipitated. On the other hand, the prevailing winds on the coast of Peru, being from the south and south-west, come from a cold to a warmer region; consequently a diminution of the degree of saturation must there take place, and the vapours remain uncondensed; accordingly it is found that rain seldom falls on that coast. The clouds which overhang the coast of Malabar during the monsoon above mentioned are arrested by the chain of the Ghauts, and while it rains on the western side the fair season is enjoyed on the coast of Coromandel. Again, the currents of air which pass over Peru, in crossing the chain of the Andes, where the temperature is lower, become condensed by the cold, and the rain is there precipitated in abundance. The vapours which come from the Atlantic Ocean, and pass over the south-western counties of England, must be more abundant than those which arrive there from the continent of Europe; and from observations made at Penzance, the rains which accompany the westerly winds at that place exceed those produced by the easterly winds in the ratio of about three to one.

In tropical regions, the quantities of rain which fall in different months of the same year are very unequal: at Bombay, the mean monthly depth in June was found to be 24 inches, and in October 1·26 inches. In temperate climates the quantities differ much less, but more rain falls during the second half-year than during the first.

In the article CLIMATE (vol. ii., col. 972) the local distribution of rain has been treated at some length, and the rainless regions of the earth particularly distinguished. An attribute of the latter, hitherto unnoticed, may now be pointed out: this is, the different condition of oxidisable and readily soluble substances in them from that characterising the same class of bodies in those countries which are ordinarily subject to rain, and in which, consequently, the earth, even in its depths, has been from time to time drenched with water during the present period of its physical history. Mr. Frederick Field, F.C.S., a chemist, who, during his residence for some years on the western side of South America, was actively engaged in the examination of its mineral products, remarks that, "In the northern part of Chili, where little or no rain falls, and the mines have only been recently worked, [and their contents, therefore, not long exposed to the action of the atmosphere,] many minerals in a highly oxidised state are found, which have been preserved untouched from the absence of any solvent. Arsenic is obtained sometimes as arsenious acid, and sulphur as sulphuric acid, in combination with the oxides of iron and copper. In Peru, even crystals of native sulphate of silver have been observed." ('Quart. Journ. of Chem. Soc.,' vol. xii., April, 1859.) In ordinary rainy countries, for the reason above stated, these substances are of rare occurrence, under occasionally favourable circumstances only.

In general the lowest stratum of air about the earth contains the greatest quantity of aqueous vapour; and hence it might be expected that more rain should fall on low level plains than in elevated countries. The contrary, however, is the fact: and this may be accounted for by the variety of currents among mountains, and by clouds resting frequently on the summits of hills without descending to the plains. While the average annual depth of rain at Keswick is 67·5 inches, in the interior of the country and on the sea-coast it is but 25 inches: and while the average depth on the St. Bernard is 63·13 inches, that at Paris is 20 inches only. Yet, from the observations of Dr. Heberden, Mr. Luke Howard, and M. Arago, it appears that the depth of rain on the level of the ground is greater than at the top of a building. The first of these philosophers found that the annual depth at the top of Westminster Abbey was 12·099 inches, while at a lower level, on the top of a house in the neighbourhood, it was 18·139 inches; and on the ground, in the garden of the house, it was 22·608 inches. M. Arago observed, from observations during twelve years, that on the terrace of the Observatory at Paris the annual depth was 50·471 centimetres (19·88 inches), while in the court of that building, which is 28 metres (30 yards) lower, the annual depth was 56·371 centimetres (22·21 inches).

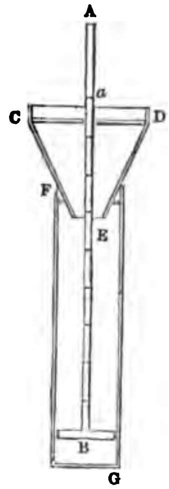
On this subject we are now able to add some precise information derived from modern research. In 1833 was communicated to the British Association for the advancement of Science, a 'Report of Experiments on the Quantities of Rain Falling at different Elevations above the surface of the ground at York, undertaken at the request of the Association,' by William Gray, jun., and John (now Professor) Phillips; to which remarks on their results were added by the latter; and the whole published in the 'Third Report' of the Association, pp. 401-412. These experiments were made at three stations; the summit of York Minster, at the height of 241 feet 10¼ inches above the river Ouse, which is nearly level with high water in the Humber; the roof of the Yorkshire Museum, at the height of 72 feet 8 inches, and at the distance of 1100 feet from the Minster; and in the Museum grounds, at the height of 29 feet, and distance of 136 feet from the Museum; the second and third stations were nearly equidistant from the Minster. These points embraced in a remarkable manner the desired conditions of gradation of altitude, openings of sky, and contiguity of position. The results for twelve months, exclusive of snow, were, in the order of altitudes, as follows:—15·715 inches, 20·182, 23·785. On these results Mr. Phillips remarks, after arranging them in relation to mean temperature and the season of the year, that the diminution of the quantity of rain received at different heights above the ground, as compared with that received on the ground, is very accurately represented by a simple formula involving one constant, namely, the square root of the height of the station above the ground, and one variable coefficient. He then examines Dr. Heberden's results at Westminster, noticed above, and finds that it is probable that they obey the same constant relation to height as those of York, but the values of its variable co-efficient are very different, a subject which he next proceeds to investigate, with reference also to Arago's observations at Paris. He finally obtains a remarkable and continued accordance between the co-efficient fixed by observation and those derived by two methods from a very simple view of the condition of the air as to heat and moisture, which appears to him decisive of the question as to the general cause of the variation of the quantity of diminution of rain at any one height above the ground. The observations strictly warrant the conclusion that the ratio of diminution at different heights is constant throughout the whole year. Professor Phillips, therefore, offers the hypothesis, as a matter of very probable inference, "That the whole difference in the quantity of rain, at different heights above the surface of the neighbouring ground, is caused by the continual augmentation of each drop of rain from the commencement to the end of its descent, as it traverses successively the humid state of air at a temperature so much lower than that of the surrounding medium as to cause the deposition of moisture upon its surface. This hypothesis," he remarks, "takes account of the length of descent, because in passing through more air more moisture would be gathered; it agrees with the fact that the augmentation for given lengths of descent is greater in the most humid seasons of the year; it accounts to us for the greater absolute size of rain-drops in the hottest months and near the ground, as compared with those in the winter and on mountains; finally, it is almost an inevitable consequence from what is known of the gradation of temperature in the atmosphere, that some effect of this kind must necessarily take place."

Mr. Howard has observed that, in this country, when the moon has south declination there falls but a moderate quantity of rain, and that the quantity increases till she has attained the greatest northern declination; and on some such results of observation the popular opinion that there is a connection between the alternations of rain and fair weather and the changes of the moon may be founded. The vexed question of the influence of the moon upon the weather appears to have received at length at least an approximative solution. Humboldt, in his 'Personal Narrative,' mentions as a phenomenon well-known to the pilots and seamen of Spanish America, the tendency to disappearance of clouds under the full moon. This meteorological fact has also been independently observed by Sir John F. W. Herschel, who was the first to recognise its importance in relation both to the radiation of heat from the moon and to the phenomena of the earth's atmosphere. The reviser of the present article has constantly observed, since Sir J. Herschel called attention to the subject, that when the full moon, or the moon so nearly full as to appear round, rises in a cloudy sky, she soon clears of cloud a circle of sky around her, which becomes larger and larger, often until the entire sky is freed of cloud. Referring to the induction of Arago, from a comparison of rain registered as having fallen during a long period, that a slight preponderance in respect of quantity falls near the new moon over that which falls near the full moon, Sir J. Herschel remarks, ('Outlines of Astronomy,' 5th edit., 432 and note), "This would be a natural and necessary consequence of a preponderance of a cloudless sky about the full, and forms, therefore, part and parcel of the same meteorological fact." [Hail; Meteorology; Mist; Snow.]

RAIN-GAUGE, a vessel for measuring the quantity of rain which falls on any particular part of the earth's surface, the quantity being indicated by the depth of the precipitated water which would cover the ground about the spot, supposing the ground to be horizontal and that the water could neither flow off nor penetrate into the soil.

In order to ascertain the quantity of rain which has fallen during the continuance of a shower, it might suffice to place a prismatical or cylindrical vessel, open at the top, in a horizontal position on the ground or on the top of a building, and, when the shower has ceased, to measure the depth of the water in the vessel by a scale of inches. But, unless the depth were ascertained immediately, a portion of the water would be carried off from such a vessel by evaporation, and the measure would be less than it ought to be. The difficulty also of ascertaining the true amount of a small depth of water would render the instrument of no practical use. For the purpose therefore of obtaining a more correct estimate of the quantity of rain, it has always been the practice to receive the water in a second vessel, or in a tube, the area of whose horizontal section is less than that of the first, so that the height of the column may be greater. And, since the heights of equal quantities of water in two prismatical or cylindrical vessels are inversely proportional to their bases, it is easy to perceive how a rod may be graduated so as to show, in inches, the depth of water in the upper vessel, and consequently the depth which would have lain on the ground if no absorption had taken place.

Originally this instrument, which has been called indifferently udometer (*ὕδωρ* and *μέτρον*), pluviometer (pluvia), and ombrometer (*ὄμβρος*, rain), was nothing more than a prismatical box, having a square base, open at the top and communicating with a prismatical box, placed vertically under it, by means of a pipe open at both ends; the area of a horizontal section of the lower box being, for the reason above given, less than that of the upper box. But it is evident that a prismatical or cylindrical vessel must retain, by adhesion to its sides and bottom, a sensible portion of the water which enters it; and consequently the depth measured in such vessel must indicate a quantity of rain less than that which has really fallen; it has therefore been customary of late to make the upper part of the vessel in the form of a funnel, or inverted cone.



The most general construction of a rain-gauge is shown in the subjoined diagram, which represents a vertical section of the instrument. The part CDE is a conical funnel, open both at top and bottom, and the lower extremity enters into the cylinder FG below, which thus receives the rain from the funnel. The rod AB passes through a perforation in a bar CD (in the direction of a diameter of the cone at its upper surface), and is attached, at B, to a circular piston, which has nearly the same diameter as the interior of the cylinder: the weight of the piston and rod is such as to allow the former to float with its upper surface on a level with the surface of the water; and the graduations, which are numbered towards B, commence from a point *a* on a level with the upper surface of the bar CD, when the piston B touches the bottom of the cylinder. A rim, of a cylindrical form, rises a little way above the upper extremity of the conical part of the funnel, in order to prevent the rain-water, which would strike the interior of the latter near that extremity, from being thrown out in consequence of the shock.

The diameter of the funnel at the top may be 12 inches, and that of the cylinder 6 inches; in which case the area of the horizontal section on which the rain falls will be to that of the cylinder in the ratio of four to one. Hence a depth of water equal to one inch at the horizontal section will be expressed by a space equal to four inches on the length of the rod; and, each of such spaces being divided into 100 parts, the depth of water at the said section will be indicated in hundredths of an inch. The height of the cylindrical vessel below the funnel may be from 25 to 30 inches.

For the sake of diminishing the evaporation and of measuring small quantities of rain with greater precision, the diameter of the cylinder is sometimes reduced to two inches, and the collected water is, by means of a small pipe, inserted in the bottom of the cylinder, and furnished with a cock made to pass into a glass tube whose interior diameter is half an inch. In this case, the diameter of the upper extremity of the funnel being the same as before, the area of the surface which receives the rain from the atmosphere will be to the area of a horizontal section of the glass tube as 576 to 1. Consequently a shower of rain whose depth on the ground might be one-hundredth part of an inch, would be indicated by 5·76 inches in the tube.

The funnel of the cylinder may be of tin or copper, and, however the instrument be constructed, it is evident that it should be placed in a vertical position in some place where no object may interfere with the free descent of the rain into the funnel. For the reasons stated in the previous article, the gauge should be placed as near the ground as possible, but the height should always be stated. At Greenwich there are several gauges, at different heights, and these record very different quantities of rain: for example, in 1846, the gauge 50 feet above the ground recorded 13·46 inches of rain; that at 24 feet, 22·63 inches; that at 2 feet, 25·86 inches. It is usual to observe the quantity of water in the vessel every morning, if rain has fallen during the preceding twenty-four hours; but, as some evaporation will take place, it would be advantageous to make the observations more frequently.

The sum of all the depths observed during any period of time, as a day, month, or year, will give the whole quantity of rain which has fallen in that time at the place. It is supposed that the rain falls uniformly over the tract of ground lying within the limits of the shower, and consequently that the quantity which passes through the circular area at the upper surface of the cone is equal to that which falls upon an equal area of ground anywhere within those limits. During windy weather rain may fall obliquely, so that a portion of it may not enter the gauge; hence, gauges have been formed with openings inclined to each of the four principal quarters, and these are said to register more rain than ordinary gauges. The *self-registering* rain-gauge is described under Anemometer.

A rain-gauge is a very imperfect instrument, and can never serve further than to give an approximation to the quantity of rain which may have fallen, since some of the water will always adhere to the sides of the vessel, but the following method of ascertaining the allowance to be made for the quantity thus lost has been recommended:—Let a sponge be made damp, yet so that no water can be squeezed from it, and with this collect all the water which adheres to the funnel and cylinder after as much as possible has been drawn off; then, if the sponge be squeezed, and the water from it be received in a vessel which admits of measuring its quantity, a near estimate may be made of the depth due to it; and this being added to the depth given by the instrument would probably show very correctly the required depth of rain.

The simplest form of rain-gauge is perhaps that by Professor Fleming. It consists of a cup or receiver, with the opening flush with the surface of the soil. The water is delivered by a funnel into a graduated jar below, which can be from time to time inspected. A small receiving vessel is preferred by some observers to a larger one. The area of the aperture must be accurately ascertained. The circular form is the best, since it admits of being turned in a lathe. The rim may be made to project, so as to retain the water which splashes up, especially in oblique showers. The divisions of the measuring jar should be tested by weighing the water. Some observers prefer to estimate the amount by weight, and an easy method of doing so is given in Drew's useful little volume entitled 'Practical Meteorology,' 1860.

RAINBOW, a circular arch of variously coloured light which is visible in the heavens when the sun or moon is shining, and when, at the same time, a shower of rain is falling on the opposite side of the spectator. When the rain is abundant, a second bow is commonly seen on the exterior, and concentric with the first; their common centre being in a line drawn from the luminary through the eye of the spectator and produced towards the opposite part of the heavens. Both bows consist of concentric bands of the different prismatic colours arranged as they appear in the solar spectrum, but the order in which they are disposed in the first bow is inverted in the second. The lower edge of the interior bow is violet and the upper edge is red; on the contrary, the lower edge of the exterior bow is red and the upper edge is violet.

The rainbow is a phenomenon which appears at all times to have been understood to depend upon the light of the sun or moon and the drops of falling rain; but the first complete explanation of the circumstances connected with it is due to Newton ('Optics,' book i., p. 2, prop. 9). In the beginning of the 16th century no better notion was entertained of the cause of the phenomenon than that the interior bow was a distorted reflection of the sun's image from the surface of a cloud, and that the exterior bow was a reflected image of the first. But the reflection of light is not capable of producing different colours, and it is said that Fleischer of Breslau (1571) was the first who entertained the idea that the particles of light from the sun entered into the drops of rain. His opinion was that a ray of light suffered one refraction on entering and another on leaving a drop; and that it entered the eye of the spectator after reflection from the surface of a second drop. It appears that Kepler, in a letter to Harriot (1606), suggested that the particles of light, in a ray which is a tangent to some part of the surface of a drop of rain, might enter the drop by refraction, and that this ray, being subsequently reflected at the interior surface of the latter, might enter the eye of the spectator after being again refracted on leaving the drop. The hypothesis is worthy of Kepler's sagacity; and, as far as it goes, it differs from the fact only in the manner in which the incident ray is supposed to fall on the drop. Newton ascribes the first idea of the true explanation to Antonio de Dominis, bishop of Spalatro, whose work, 'De Radiis visûs,' was published in 1611, but is said to have been composed in 1590: the work however appears to have been so obscurely written, and to betray so much ignorance of the laws of optics, that it is doubtful whether or not the author had any more than a vague conception of the cause of the colours. (See Montucla, 'Histoire des Math.,' tom. ii.)

Descartes is certainly the first who has distinctly explained the causes by which the two bows are produced, and he states ('Meteora,' cap. viii.) that he detected those causes on observing the phenomena presented by a glass globe filled with water, which he placed in various positions with respect to the sun. He shows that the interior or primary bow is produced by rays from the sun falling upon the drops of rain near their upper surfaces, where, being refracted, they pass to the side of the drop which is farthest from the sun and spectator; from thence they are reflected towards the lower surface, and, on quitting the drop, they suffer a second refraction. He shows also that the exterior or secondary bow is produced by rays from the sun falling upon the drops of rain near their lower surfaces, where, being refracted, they pass, as before, to the farther side of the drop; from thence they are reflected towards the upper surface, and there they suffer a second reflection. After this they pass to the side of the drop which is nearest to the sun, and from thence they emerge after a second refraction.

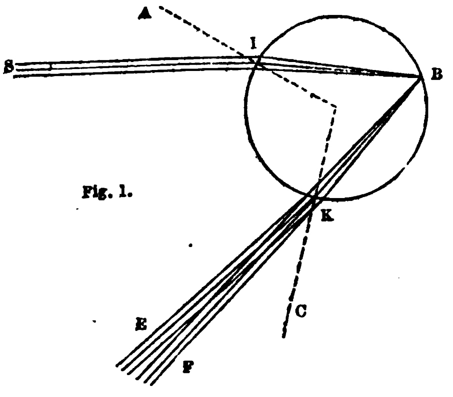


Fig. 1.

Now it is not sufficient that the pencils of light which are incident on the drops of rain should be so refracted and reflected; it is moreover necessary that each pencil on emerging from the drop should consist of parallel rays of light, that, when it enters the eye of the spectator, it may produce in the mind the perception of brightness; and Descartes determined by computation the positions of the incident and emergent rays so that this effect may be produced.

Thus, let SI (*fig.* 1) be a very slender pencil of rays of some one colour incident on a spherical drop of water at the angle AIS, and let this angle be such that the rays in the pencil may, by the laws of refraction in water, converge at B; then, though many rays will pass through the drop at that point and be dispersed, yet many will be reflected from thence as from a radiant point, and will emerge at K in parallel directions, as they entered at I, so that if KE be the direction of the emergent pencil, the angle CKE will be equal to AIS: the angle made by the lines SI and EK produced was found by Descartes to be about 42 degrees. If the angle AIS were varied, the rays of the pencil would leave the drop in a divergent state, and then the impression which they would make on the eye might be too feeble to produce the sensation of brightness. Again, let SI (*fig.* 2) be a very slender pencil of rays of some one colour incident on a spherical drop of water at the angle AIS, and let this angle be such that, by the laws of refraction in water, the rays, after crossing at X and being reflected from B, may pass from B to C in parallel directions; then, after a second reflection, crossing at Y and being refracted at K, they will emerge in parallel directions as they entered at I, so that if KE be the direction of the emergent pencil, the angle DKE will be equal to AIS: the angle made by the lines SI and EK was found by Descartes to be about 52 degrees. If the angle AIS were varied, the rays of the pencil would leave the drop in a divergent state.

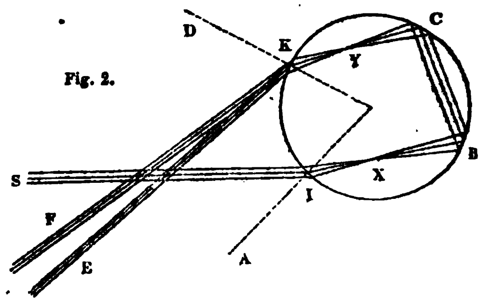


Fig. 2.

Now let A, B, C, D (*fig.* 3), be four globules of rain in a cloud covering a considerable part of the heavens on one side of the horizon. Let E be the eye of the spectator, and, on account of the remoteness of the sun, let the rays of light which proceed from his disc be considered as parallel to one another. Let SE be a line drawn from the sun through the eye of the spectator, and let it be produced towards O; also let SA, SB, &c., be very slender pencils of parallel rays (supposed at present to be of one colour) falling upon the globules of water. Let the refraction and reflection of these pencils in A and B be similar to those which are shown in *fig.* 1; and the refraction and reflection in C and D be similar to those in *fig.* 2; also from the points of emergence suppose lines to be drawn to E. It is evident, on account of the parallelism of the lines SO, SA, &c., that if the angle AEO or BEO were nearly equal to 42°,

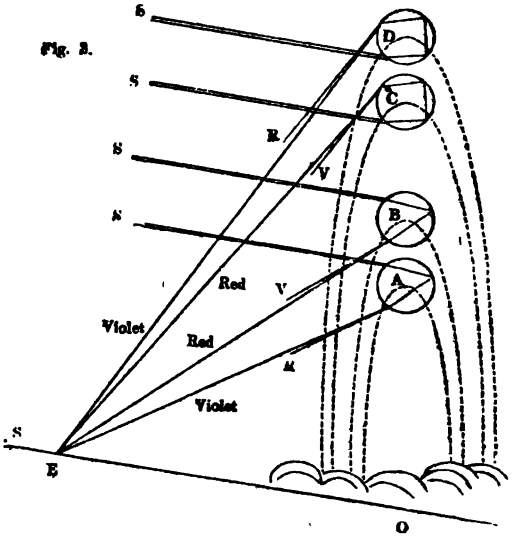


Fig. 3.

and if the angles C E O or D E O were nearly equal to 52°, the eye would be affected by the sensation of brightness as explained above; therefore, if the lines A E, B E, &c., were to revolve conically about E O as an axis, all the globules of rain upon the conical surfaces so described would send pencils of parallal rays to the eye, and two concentric arches of bright light would be seen in the heavens. This hypothesis accounts satisfactorily for the existence of two concentric bows of bright light, but it affords no indication of the bands of colours of which they consist. Descartes, however, very sagaciously refers their cause to the decomposition of light on entering and quitting the drops of rain, observing that the convex surfaces of the drops must produce effects similar to those which take place when light is made to pass through the plane faces of a triangular prism of water.

But when Newton had discovered the different degrees of refrangibility in the different coloured rays which composed a pencil of white or compounded light, he was able to assign immediately the cause of the coloured bands in the rainbow, the order of their position, and the breadth which they must occupy. Thus, if the incident pencil S I (*figs.* 1 and 2) had consisted only of violet-coloured light (for example), the angle A I S must have had that particular value which alone would allow the rays of the emergent pencil to be parallel to one another; but if the incident pencil were supposed to consist of light of another colour, as red, it should have fallen a little further from the centre of the drop, in order that the angle A I S might have the particular value which would allow the rays of the emergent pencil to be parallel to one another. It may be proved without difficulty that the total deviation, when consecutive emergent rays of a given colour come out parallel to one another, is less for red rays than for violet; and if K E be the direction in which the latter emerge from a drop, K F in both figures may represent the direction in which the former would emerge, the variation of the course before emergence being omitted in the figures to avoid confusion; and if the eye were situated so as to receive the pencil K E, it would have the impression of a violet colour; while, if it were situated so as to receive the pencil K F, it would have that of a red colour. We have mentioned, for simplicity, only the violet and red rays, which form the two extremes of the coloured spectrum; but it is easy to conceive that a like explanation might be given for rays of the intermediate colours. And since the pencils of all the different colours diverge from one another on quitting a rain-drop, it is evident that the spectator whose eye receives one of the pencils will be affected by the colour of that pencil only, the other pencils passing either above or below his eye.

Newton has determined by computation that when the angle A E O (*fig.* 3) = 40° 17′, the violet rays alone, after two refractions and one reflection, will enter the eye of the spectator at E, the other rays falling below; and when ∠ B E O = 42° 2′, the red rays alone will enter the eye, the violet rays passing above. Again, when ∠ C E O = 50° 59′, the red rays only will enter the eye, after two refractions and two reflections, the violet rays falling below; and when ∠ D E O = 54° 9′, the violet rays alone will enter, the red passing above. If the interval between the drops A and B, and also between the drops C and D, were occupied by other drops, it may readily be imagined that the pencils of parallel rays which come from them to the eye would be of all the prismatic colours between the red and violet, and that thus there would appear in the heavens two narrow spectra: the length of that between A and B would be 1° 45′, and of that between C and D would be 3° 10′. Therefore, if all the lines drawn to E from the drops in the two spectra were to revolve conically about E O as an axis, the drops on these lines would be in situations to send to the eye rays of their own proper colours, and thus there would exist the appearance in the heavens of two concentric bands of variously coloured light.

But it has been here supposed that the pencils S A, S B, &c., come from the centre only of the sun's disc, whereas each point of the disc produces two bows similar to those which have been described; therefore the lower extremity of the interior bow will be a violet band whose breadth is equal to half the diameter of the sun (suppose 15′), and which is situated immediately below the violet line formed by the centre of the disc; and in like manner the upper extremity of the interior bow will be a red band whose breadth is also = 15′, and which is situated immediately above the red line formed by the centre of the disc: consequently the whole breadth of the interior bow is about = 2° 15′. Similarly 30′ (the measure of the sun's diameter) must be added to the breadth of the outer bow, as before determined, which thus becomes about = 3° 40′. In both bows, the colours between the violet and red are less distinct than those two colours, because of the mixture of the coloured light from all parts of the disc.

On account of the two reflections which take place in the interior of the drops which give rise to the outer bow, while there is but one reflection in those which produce the inner bow, there must be a greater quantity of light lost by transmission through the drops in the former case than in the latter; and hence the outer bow is always fainter than the other.

The effect of the light of any given colour which comes out of the drop in a divergent state has been neglected in the preceding investigation, but it is by no means insensible, especially in the neighbourhood of the bow, where the divergence is not great. If a ray which emerges after one or two internal reflections be first supposed to be incident along a line passing through the centre of the drop, and the line of incidence be then conceived to move parallel to itself until having passed through S I in *fig.* 1 or 2, it just grazes the surface, it will be found by calculation that the deviation, at first 180° or 360°, decreases until the position is reached in which consecutive rays come out parallel, after which it increases again. In *fig.* 1, the deviation takes place in the direction of the motion of the hands of a watch, and in *fig.* 2 in the contrary direction. Hence the rays which emerge with greater deviation than K E, are situated (as to their directions) *above* K E in *fig.* 1, and *below* K E in *fig.* 2; and therefore in *fig.* 3 the drops to which they refer would be situated *below* A or B in the former case, and *above* C or D in the latter. Hence, considering light of one colour only, and again regarding the sun as a mere point, we ought instead of two bright circles in the sky, in the positions determined above, to have two bows, in each of which the brightness terminates abruptly on the side towards the other, and fades off on the other side. Hence, considering the joint effect of all the colours, we see that they must be more mixed together, especially about the blue and violet, than would otherwise have been the case. In a vivid solar rainbow the darkness of the space between the bows compared with the space immediately within the primary bow is readily seen.

There is one part of the phenomenon which cannot be explained merely by geometrical optics, namely, the existence of what have been called *supernumerary bows.* In the upper part of the primary solar rainbow two or even three maxima of red may frequently be seen on the inside of the principal maximum, forming as many additional or supernumerary bows, decreasing in vividness and in breadth on receding from the principal bow inwards. Even the secondary bow, notwithstanding its comparative faintness, shows symptoms of the same phenomenon. The existence of these bows was first explained by Dr. Young, who pointed out that the light corresponding to any particular direction within the bow was double, and that the two portions were in a condition to interfere. The explanation, however, resulting from the application of the principle of interference to two systems of rays whose courses are determined by geometrical optics is imperfect, and would make the illumination increase to infinity on passing from the illuminated side to the place of the geometrical bow, and then ceases abruptly. Whenever such results follow from the calculations of geometrical optics, it is found that they are modified in practice by the phenomena of diffraction. The complete explanation of the supernumerary bows, according to the principles of the undulatory theory, has been given by Mr. Airy, in a paper 'On the Intensity of Light in the neighbourhood of a Caustic' ('Camb. Phil. Trans.,' vol. vii., p. 379), and his results have been verified by the observations of Professor Miller.

A rainbow can never be greater than a semicircle, if the spectator be not on elevated ground; for if it were, the centre of the bow would be above the horizon, and the sun, which is in a line drawn through that centre and the eye, would then be below the horizon; but, in this case, the sun could not shine on the drops of rain, and consequently there would be no bow. When the rain-cloud is of small extent, there is seen only that portion of the bow which the cloud can form; yet the bow is sometimes seen against the blue sky, which happens when the rain in falling is seen on a part of the sky which is free from cloud; and a portion of a bow is frequently seen in an inverted position on the ground by the refraction of the light in drops of rain adhering to the grass or the leaves of trees. It may be added that a coloured bow similar to that which is produced by rain may be observed in the spray from a waterfall, or from a fountain, when the jet of water is agitated by the wind, and also in the mists which at times lie upon low grounds.

The lunar rainbows appear in general in white; and when they are coloured, they differ from those produced by the sun only in the colours being much more faint. The faintness of the colour, or its entire absence, is accounted for by the fact that when light is excessively faint, all perception of colour is lost.

The circle of light which is occasionally seen surrounding the sun or moon at a considerable distance from the disc of the luminary is called a *halo*, and is caused by the refractions of light in particles of ice which float in the air. It must not be confounded with a *corona*, which consists in one or two coloured rings immediately surrounding the luminary, and is distinguished from a halo by the variability and comparative smallness of its diameter, and by the order of the colours, —red outside, blue inside—which is the reverse of the order in a halo. The corona is due to the globules of water constituting a thin veil of cloud, and is a phenomenon of interference, which may be imitated by viewing a candle seen against a dark background through a piece of glass dusted with lycopodium. The two halos most commonly seen have radii of about 22° and 46°. The phenomenon of halos having some resemblance to that which has been just described, a brief explanation of it may be with propriety introduced in this place.

The cause of the halo was first investigated by Des Cartes, who observes ('Meteora,' cap. ix.) that this phenomenon differs from the rainbow, inasmuch as the latter is seen only while rain is falling, whereas halos are never seen at such times; and he ascribes their formation to refractions of light in star-shaped crystals of ice, which he remarks are thicker in the middle than at the edges, and are therefore proper to produce refractions.

Sir Isaac Newton also ascribes the halo to refraction in floating hail or snow; but it appears that Mariotte (in 1686) was the first who considered it to be produced by refraction in the small equilateral prisms of ice which abound in the air in a separate state before they unite together and form the flakes which descend during severe frosts; and Dr. Young, without being aware of Mariotte's hypothesis, entertained and developed the same idea.

According to this philosopher, there may be in the air an immense number of prismatic particles whose transverse sections are equilateral triangles, or equiangular hexagons, the planes of the sections deviating but little from one passing through the sun or moon and the spectator. Now by the laws of refraction in water, when a pencil consisting of parallel rays of light, as S I (*fig.* 4) is incident on a face of such prisms and makes the angle of incidence S I P equal to about 41° 50,′ the axis K E of the emergent pencil will make an equal angle E K Q on the other face, and the angle of deviation S A F, or the angle between the incident and emergent ray, will be 23° 40′. Therefore if the line F E produced to the spectator's eye were to revolve conically about a line joining the sun and spectator as an axis (which line, since the sun is very remote, may be considered as parallel to S A), all the prisms similarly situated on such conical surface would transmit to the eye pencils of parallel rays, if the light were of one colour, and thus there would be produced the perception of a bright circle in the heavens, having the sun for its centre; its radius subtending at the eye an angle of about 23° 40′. The angle S A F varies very slowly, the variation amounting only to about 3°, when the angle S I P varies as much as 30°, consequently there may be innumerable prisms in the air in such positions that the angle S I P, for pencils incident upon them, does not vary more than 15° on either side of that which has been above supposed; and these will transmit to the eye light in such abundance as to produce the appearance of an annulus about 3° broad. This is the appearance of the common halo, the slight excess of the calculated radius over that observed being accounted for by the fact that water is a little more refractive than ice.

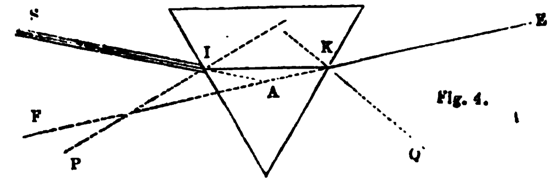


Fig. 4.

The larger halo is accounted for in a similar manner, by refraction through ice prisms of 90°, this angle being contained between the plane ends and side faces of hexagonal prisms of ice. The radius, calculated with 1·310 for the refractive index of ice, is about 45° 46′, which agrees very well with the angle observed.

The horizontal parhelia which are seen at the same altitude as the sun, a little outside the smaller halo, are accounted for by refraction through prisms of ice of 60°, which, instead of being placed on the average alike in all directions, have their axes vertical, in consequence of the resistance of the air as they fall under the influence of gravity. As the incident and emergent rays make with the axis of the prism an angle equal to the zenith distance of the sun, the minimum deviation is greater than what corresponds to refraction in a plane perpendicular to the axis of the prism, which accounts for the parhelia being situated a little outside the halo. This is the commonest example of that curious class of halo phenomena, where the appearance is no longer the same (except as to interruptions in the icy clouds) all round the line joining the eye and the sun, but has reference to the vertical. The reader who desires further information on this point is referred to an elaborate memoir by M. Bravais in the 31st *cahier* of the 'Journal de l'École Polytechnique,' where the subject is almost exhausted.

RAISINS. The dried fruits of several varieties of the vine are called raisins, a term derived from the French: raisin in that language being a general name for grapes, the dried fruit being distinguished as *Raisins secs ou passés.*

Raisins are named after the countries where they are produced, or the places whence they are imported; as Malaga, Valencia, and Smyrna. The peculiar small and generally seedless grapes, formerly called *Corinths*, are now better known as the dried or Zante *currants* of the shops. Other denominations by which different kinds of raisins are distinguished, arise from the variety of grape employed, or from the mode of preparation; as muscatels, blooms, sultanas, raisins of the sun, and lexias.

The most simple, and, when circumstances are favourable, the best mode of preparation, is to dry the grapes, after being cut when fully ripe, by exposure to the heat of the sun on a floor of hard earth or of stone. Another method is to cut the stalk half-way through when the grapes are nearly ripe, and leave them suspended till the watery part is evaporated; the flow of sap is in a great measure prevented from entering the fruit, in consequence of the incision, and whilst evaporation continues to go on undiminished, desiccation must take place. Some sorts are prepared by dipping the grapes in a ley, and afterwards drying them in the sun. This ley is formed of water, wood-ashes, and a small portion of olive oil. The ashes of vine branches and tendrils are preferred. In Valencia, in addition to the ashes of rosemary and vine branches, a little slaked lime is used. Raisins so prepared are called lexias; whilst those prepared entirely by sun-heat are denominated raisins of the sun. A fourth method, only used for raisins of inferior quality, is to dry the grapes in an oven.

The *currant*-grapes are gathered in the end of August and beginning of September. Rains often spoil the crop when they occur at the time of gathering or drying. The fruit, when sufficiently dry, is separated from the stalks by small rakes, and afterwards stored in magazines, *seraglie*, constructed somewhat like a lime-kiln, having an opening at top, where the fruit is put in, and a door at bottom, opened only at the time of sale. The fruit is rendered so compact by its own weight, that considerable force is requisite to break it up for the purpose of being packed in the large casks in which it is exported.

Of all the known varieties of grapes, the white muscat of Alexandria is that which furnishes raisins of the finest description. The berries are large, oval, white, rather firm-fleshed, with a rich muscat flavour.

From the synonyms which it has obtained, its extensive cultivation and use as a raisin grape may be inferred; for example, it is called the muscat of Jerusalem, Malaga, Passé-Musquée, Passé-Longue Musquée, Muscat d'Espagne, &c. There is also a black muscat of Alexandria, and a red muscatel, both of which have a firmness of pulp which renders them fit for drying; for grapes, however rich they may be, and excellent in a fresh state, yet if they do not possess a certain degree of firmness, are unfit for drying, inasmuch as their substance would be too much dissipated in the process.

The variety of grape-vine that bears the small and generally seedless bunches of grapes, which, when dried, become the *Corinths* or *Zante currants* of the shops, belongs to *vitis vinifera.* The berries of those grown in this country have the same size and character as those imported, being small and seedless, except occasionally one that acquires a somewhat larger size and contains a seed; such are even found amongst imported fruit. The first grapes of this variety that appeared in the great marts of Europe were brought at the beginning of the 17th century from the Gulf of Corinth, and hence were called *Corinthian* raisins. Latterly however the cultivation has become chiefly confined to the western territories of the Morea and the Ionian Islands, particularly those of Zante, Cephalonia, and Ithaca. The fertile island of Zante is the place where this variety of grape is produced in greatest abundance.

Nearly all the raisins imported into this country come from Spain and Turkey. A small supply is received from Portugal, Italy, and the Cape of Good Hope. Malaga and Valencia are the two great Spanish ports of shipment. Nearly the whole of the supply from Turkey is shipped at Chesmé and Vourla, small ports near Smyrna, the only raisins shipped at Smyrna being the small fine species called sultanas. Chesmé owes its prosperity entirely to this trade; and the Franks go down there in the month of October merely to ship the fruit which is produced in great abundance in the vicinity.

Raisins are imported in drums of 24 lb. each, in boxes of 22 lb. and 56 lb., and in casks of 1 cwt. and 2½ cwt. The import duty was fixed in 1860 at 7*s.* per cwt. In 1859 the imports were 558,000 cwt. of currants, and 429,000 cwt. of raisins. A small per centage of the imports, however, is re-exported, with a drawback of duty.

RAJA is a Sanscrit word, signifying king or ruler, and is the same word as the Latin *rex, reg-is.* In the ancient writings of the Hindus the word is applied to all the different kings or princes of Hindustan, and the title is still given to native princes.

RAMA. [VISHNU.]

RAMADHA'N, the ninth month in the Arabian calendar, and a sort of Lent observed by the Mohammedans, in obedience to the express command of the Koran. During this month every good Moslem is bound to fast from the first appearance of day-break until sunset. He must abstain from eating, drinking, smoking, smelling perfumes, and all other unnecessary indulgences or pleasures of a worldly nature; even from intentionally swallowing his spittle. He is allowed to bathe himself, but it is on condition that he is not to plunge his head under water, lest some drops should enter his mouth or ears. Some even are so scrupulous that they will not open their mouths to speak, for fear of breathing the air too freely. To make amends for this extreme rigour, Moslems generally feast all night till day-break, though the more rigid begin the fast again at midnight. As the Ramadhán happens at different seasons of the year, the fast is very severe when it falls in summer; the abstinence from drinking being most painfully felt. Persons who are sick, or on a journey, and soldiers in time of war, are not obliged to observe the fast during this month, but then they should fast an equal number of days at a future time. Fasting is also dispensed with in the case of nurses and pregnant women. The prophet even disapproved of any persons keeping the fast of Ramadhán, if not perfectly able; and he desired no man to observe it so strictly as to injure his health or disqualify himself for necessary labour, which is frequently the case among the lower classes of people. The reason given by the Mohammedan theologians for the month of Ramadhán having been fixed upon for this purpose is, that the prophet received his first revelation in that month; others pretend that it was chosen by Mohammed from its being generally spent by the ancient Arabs in revelry and mirth and excessive drinking.

RAMPART, probably from Ripa, an embankment, from which is derived the Italian word "Riparo," and the French word "Rempart," is, in modern fortification, a mass of earth often nearly 80 feet thick, surrounding a town or a military position, or constituting the faces of an outwork, and supporting the parapet; and its use is to protect the interior of the place or work against any sudden enterprise of the enemy, as well as by raising the parapet to give the defenders a superiority of elevation with respect to the works of the besiegers.

The ramparts of ancient fortresses were walls of stone or brick, frequently from 60 to 100 feet high and 20 feet broad, including the galleries made in them: round or angular towers were formed at intervals along the walls; and, by means of the galleries, the defenders could pass within the thickness of the wall from tower to tower. The rampart was surmounted by a parapet seven feet high and two feet thick, which was provided with battlements; the rampart was loop-holed, and, in order that the exterior foot of the high wall might be defended, machicolations were formed at the top, particularly over the entrances. [Bastion.] A great mass of earth was raised against the interior side of the walls, nearly as high as the top, in places where elevated ground or the enemy's works on the exterior allowed access to the top of the wall to be gained in force: and on this mass the cohorts were drawn up in order of battle. (Vitruvius, lib. i., cap. v.)

The modern rampart is surmounted by a parapet of earth, on the interior side of which, towards the town, is a nearly level space, varying in breadth from 35 to 40 feet, called the terreplein of the rampart; on this terreplein the artillery is placed: and in the rear of the guns there is room for the movements of the defenders and the conveyance of the ammunition. The exterior and interior sides of the rampart are formed with slopes making angles of about 45 degrees with the horizon: or they are retained by revetments, or walls of brick or stone, nearly upright, the exterior face of the rampart constituting the *escarp* of the ditch in front. The rampart immediately surrounding a place is divided, in the direction of its length, into parts making salient or re-entering angles with one another; and these parts constitute the faces and flanks of the bastions, and the curtains which connect the latter together. Not more than 30 feet are allowed for the breadth of the terrepleins of the ramparts of outworks, measured from the foot of the parapets, in order that the enemy may not be able to form batteries for artillery upon these terrepleins. The terrepleins of all ramparts should have a small slope down, towards the interior, in order that the rain-water may not lodge on them, and that the defenders near the interior edge of the rampart may be effectually covered by the parapet. The terreplein and the interior slope of a rampart, as well as the surface of the parapet, are generally covered with turf. A rampart whose exterior side is of earth, or without a revetment of brick or stone, might be easily ascended by an enemy at the time of an assault; and the palisades or fraizes which, in that case, would be planted in it for the purpose of impeding the progress of the enemy, might be easily destroyed by artillery, so that the place would be liable to be carried by a sudden assault. It is usual therefore always to have a revetment either supporting the earth or *detached* (see Revetment), except in cases where a *coup-de-main* is rendered impossible by wet ditches.

The relief, or height, of a rampart is regulated by the occasional necessity of employing a fire of artillery from the rampart, and, at the same time, a fire of musketry made over the glacis by men stationed in the covered way beyond the ditch in front of the rampart: for this purpose a line of fire from the rampart should pass three or four feet above the crest of the glacis in its front, in order that the wind of the shot may not injure the defenders. The relief of a rampart with its parapet may, therefore, be thus determined:—On a drawing representing a vertical section of the works let a line be drawn from the foot of the glacis, through a point taken at 3 or 4 feet above the crest of that work, and let it be produced till it cuts the interior slope of the parapet on the rampart: this intersection will give a point in the axis of a gun placed on the rampart, or a point a few inches above the sole of the embrasure, that is, about 3½ feet above the terreplein of the rampart; and, because the artillery and the gunners are to be protected by the parapet, if 7½ or 8 feet be added to the height of the terreplein of the rampart, above the ground, the sum will be the required height of the crest of the parapet.

RANGE. [Gunnery; Projectiles.]

RANGER (*Rangeator*), an ancient officer in the king's forests and parks, appointed by patent, and enjoying certain fees, perquisites, and other advantages. His duty was of three kinds: 1, to make daily perambulations, to see, hear, and inquire concerning any wrong doings in the limits of his bailiwick; 2, to recover any of the beasts which had strayed beyond the limits of the forest or chase; and, 3, to present all transgressions at the next forest-court.

RANSOM, a word common to the French (rançon) and English languages, the sense of which is a sum of money paid for the redemption of a captive.

The paying of ransoms is an event of frequent occurrence in the middle-age history, and indeed may be traced in the history of the older nations. Nothing appears on the first view more reasonable, or would more naturally arise out of the relations of two parties in a state of hostility, than that compensation of some kind should be made for the restoration of prisoners, which compensation was most easily estimated and discharged by means of the common medium of exchange. In modern warfare we hear little of ransoms. It rarely happens that a person is taken captive whom it is of importance to redeem; and when prisoners are to be redeemed, it is usually done by way of exchange, and those who remain over, at the conclusion of a war, are usually delivered up as a part of the concession of the party in whose favour the difference is found to be.

In the indentures of military service in the middle-age period, as in the wars of Henry V., for instance, it was a usual stipulation that, while the ransom of persons of inferior condition taken in the war was allowed to those by whom they were captured, the ransom for persons of rank was to belong to the king.

The ransoms demanded for persons of eminence were often very large sums of money; so much beyond the power of any family, however great, to command by the ordinary resources, that the persons who held lands of them were called upon to contribute in proportion to the extent of land held. It was one of the three casual occasions of expense when this kind of extraordinary aid was demanded as of prescriptive right by the sovereign, as in the case of Richard I. of England, of David Bruce of Scotland, and of John of France; the other two being on occasion of knighting the eldest son, and of marrying the eldest daughter.

RANULA is a tumour formed beneath the tongue, and probably resulting from an obstruction of one or more of the ducts of the sub-lingual salivary glands. The tumour is usually of a rounded form, with a smooth polished surface similar to that of the adjacent mucous membrane. When small, such a tumour produces so little inconvenience, that it is usually not discovered till it has existed for some time. As they increase in size however, these growths, though seldom attended with pain, produce great inconvenience, by obstructing all the movements of the tongue. They usually burst when they have attained the size of a walnut, but they sometimes continue to increase beyond this size, and have been seen large enough to contain a pint of fluid. Their most usual contents are a transparent yellowish viscid fluid, resembling in consistence the white of an egg; sometimes, however, the material within them is much thicker, and sometimes mixed with portions of earthy matter, similar to the larger masses by which the salivary ducts are occasionally blocked up.

The treatment of Ranula consists in making a free incision into the front of the tumour, so as to let out all its contents. Means must then be adopted to prevent the edges of the wound from uniting again; and the best plan for this purpose is to rub the surface of the cyst with nitrate of silver (lunar caustic). If the wound be not prevented from uniting, the tumour will form again, and the same proceedings must again be adopted for its cure.

RANZ DES VACHES ('Kuhreihen' in German) is the name of certain simple melodies which are great favourites with the mountaineers of the Alps of Switzerland, and which are commonly played upon a kind of long trumpet called the Alp-horn. The sounds of these tunes, as well as the words which are set to them, are expressive of the scenes and business of pastoral life; the hut, the roaring torrent, the bellowing of the cattle, and the tinkling of the bells which are suspended from their necks; and the associations which they thus recall to the minds of the natives when they are in foreign countries, often produce that unconquerable longing for home which is said to have been especially remarked among the Swiss soldiers on foreign service; for this reason, the bands of the Swiss regiments in foreign service were forbidden to play the Ranz des Vaches. Theodore Zwinger, of Basel, wrote, in 1710, a 'Dissertation on Nostalgia,' in which he gave the music of the Kuhreihen of Appenzell, which is one of the oldest, and which was introduced into England in the time of Queen Anne, who had it often played by her band. The words begin thus: "Wänder yha, wänder yha, wänder yha, Lo . . . . ba." Each of the various pastoral districts, the Oberland, the Emmenthal, the Entlibuch, the Appenzell, the Gruyère, has its Kuhreihen. The western or Romand districts of Switzerland have their Ranz des Vaches in their respective patois or dialects.

A collection of the various Ranz des Vaches and other Swiss airs has been published: *Sammlung von Schweizer Kuhreihen und Volksliedern*, Bern, 1818; and they are included in the *Allgemeine Schweizer Liederbuch*, published in 1851.

RAPE is the having unlawful carnal knowledge of a woman against her will, and is a capital felony. A person under fourteen years of age is in law presumed to be incapable of perpetrating this offence: this presumption however is based on physical grounds entirely, so that such a person, by assisting others of maturer age, may render himself liable to the full penalty of the law as a principal in the second degree. In the case of a female under ten years of age, whether the act takes place with or without her consent, it is equally punishable as rape; if she be above ten and under twelve years of age, her consent reduces the act to a misdemeanor punishable by imprisonment and hard labour for such term as may be awarded.

An assault with intent to commit a rape is a misdemeanor punishable by imprisonment for any term not exceeding two years, and with or without hard labour, at the discretion of the court before which the offender is convicted. Upon a trial for the capital offence, where the evidence is incomplete, the prisoner may be convicted of a misdemeanor.

RAPE. This plant, which is of the cabbage tribe, is cultivated like cole, or colza, for the sake of its seeds, from which oil is extracted by grinding and pressure. It is also extensively cultivated in England for the succulent food which its thick and fleshy stem and leaves supply to sheep when other fodder is scarce.

The mode of cultivation of the colza and rape for seed is nearly the same. The colza takes a longer time to come to maturity, and produces more seed. The rape grows on less fertile soils, and may be sown in spring as well as in autumn. Both are hardy, and resist the winter's frost.

The colza (*Brassica oleracea, or campestris*) is a plant which grows with a strong branching stem, 3 or 4 feet high, and requires room to spread; and as cultivated in Belgium the plants are raised in a seed-bed, and transplanted when they have acquired a certain size. When rape (*Brassica napus*) is cultivated for the seed, it is treated in the same manner; one description will therefore serve for both.

The seed-bed, where the cultivation is on a small scale, is usually prepared by digging or trenching with the spade, in a good loamy soil, neither too sandy nor too wet. A large proportion of rotten dung is spread evenly over it, and dug in six inches deep, and the surface is raked fine. The seed is sown broad-cast or in drill; the latter is the best method: it is then slightly covered with the rake; and if the ground will allow of it, without risk of its being bound too hard in case of dry weather, it is well rolled or trod with the feet. The seed must not be sown too thick; and the plants, as soon as they have six leaves, must be thinned to a distance of four or five inches in the rows, which will make them stronger and better furnished with roots. One acre of seed-bed will furnish plants for ten acres or more. The seed is sown in July or August, that the plants may not run to seed the same year, which they are apt to do if sown early; and they are transplanted in September or October, on land which has already borne a profitable crop. As this crop is a substitute for a fallow on rich heavy land, too much pains cannot be taken to keep it free from weeds. Winter barley, and rye, which are reaped early in July, are very proper crops to be succeeded by rape or colza. The stubble should be ploughed two or three times, to pulverise and clean it. A good coat of rotten dung should be put on, and the land ploughed in ridges, as for turnips: the plants should be put in on the ridges ten inches apart. It requires great care in taking them up not to break the fibres of the roots: they should be raised with a fork, and placed gently, with the fine earth adhering to them, in flat baskets, and in a slanting position, so that the tops may be upwards. In planting, the holes should be made with a large thick dibble, that the plants may be introduced without doubling up the principal roots or breaking the fibres. The earth should be pressed to the root by a short dibble, inserted to the right or left of the hole made by the first dibble; or, which is better in stiff soils, a hole should be made with a narrow hoe of sufficient depth to allow the plant to be placed in it, and another hoe should follow to draw the earth to the plant. Thus two men with hoes, and one woman, will plant a row more rapidly than could be done any other way; the man who fills up the holes places his foot by the side of each plant as he goes on, to press the earth to the roots.

An expeditious mode of planting rape is used in Flanders. A spade ten inches wide is pushed vertically into the ground, and, by drawing the handle towards his body, the labourer makes a wedge-like opening; a woman inserts a plant in each side in this opening, and when the man removes the spade, the earth falls back against the plants. The woman puts her foot between the two plants, and they are then fixed in their places. In this operation the man moves backwards; and the woman, who puts in the plants, forward. Instead of the spade, an instrument is also used called a *plantoir*. It consists of two sharp-pointed stakes a foot or more apart, connected by a cross-handle at top, and a bar at about eight or ten inches from the points. The instrument is pressed into the ground by the handles, assisted by the foot placed on the lower bar, and makes two holes, a foot apart, into which the plants are placed, and earthed round as before. This is done when the land has not been laid up into high ridges.

When a large field is to be planted, a more expeditious mode is adopted; and this is the most usual practice in Holland and Germany. The land having been prepared, and the manure well incorporated, a deep furrow is drawn with the plough; women follow with baskets of plants, which they set, a foot apart, slanting against the furrow slice. When the plough returns, the earth is thrown against these plants; and a man or woman follows, who, with the foot, presses the earth down upon the roots. Sometimes plants are put into each furrow, which is then ten inches or more wide; but the best cultivators put them only in every alternate furrow. In this case also there are no ridges. The season of the year affords sufficient moisture in the north of Europe to ensure the growth of the plants; and if they have escaped the fly in the seed-bed, they are now tolerably safe. No further attention is requisite till spring. The weeds are then carefully extirpated by hand and hoe; and where the distance of the plants admits of it, the light plough stirs the ground between the rows, throwing the earth towards the stems, yet so as to leave each plant in a little basin to catch the water and conduct it to the roots. When the plants are invigorated with rich liquid manure, such as night soil mixed with water, or the drainings from dunghills, they become extremely luxuriant; and every trouble or expense bestowed upon them is amply repaid. The difference between a crop partially neglected and another carefully cultivated often exceeds fifty per cent.

There is not much difference between the value of colza and rape-seed (called *navette* in French); but the latter produces less. When the rape is transplanted before winter, it is much more productive than when sown in spring. In the latter case it produces seed the same year. It is sown in drills, and thinned out by the hoe, and in favourable seasons a tolerable crop is obtained. It is generally sown on land which could not be brought into a proper tilth after harvest, and which would require the frost of winter to mellow it.

Great crops of cole-seed and rape have been produced in the fens of Lincolnshire and the alluvial soils in Essex, by merely paring and burning the surface and ploughing in the ashes; and these crops, alternating with oats, have in many instances so exhausted the soil as to cause a great prejudice against them in the minds of the landlords. Many leases have a clause prohibiting their cultivation, except to be eaten green by sheep. The principal cause, however, of the diminution of this crop in England is the inferior price obtained for the seed when compared with wheat, which can be raised on the same land, and is a more certain crop.

The rape and colza ripen their seed very unequally. The lower pods are ready to burst before those at top are full. If the season is wet at harvest, much of the seed is lost; and, without great attention, some loss is sustained in the most favourable seasons. It should be cut when the dew is on it, and moved as little as possible. If the weather permits, it is threshed out on a cloth in the field, and as many threshers are employed as can be conveniently collected, that no time may be lost, when the weather is fair. The seed is spread out on the floor of a granary that it may not heat, and is turned over frequently. It is then sold to the crushers, who express the oil. The pods and small branches broken off in threshing are much relished by cattle. This crop returns little to the land, and is of itself very exhausting. Not so, however, is the rape, when sown as food for sheep. It is, on the contrary, a valuable substitute for turnips, upon land which is too wet and heavy for this root. The *Brassica oleracea* is more succulent than the *Brassica napus*. Its stem is not so hard, and the soft pith which it contains is much relished by every kind of live-stock. To have it in perfection, the land should be prepared and manured as for turnips. The rape should be sown in drills ten inches apart, in June, July, or August. It will be fit for consumption before winter, during winter, or after winter, according to the period of its seedtime. In the last case, in the end of March and beginning of April it will be a great help to the ewes and lambs. It will produce excellent food till it begins to be in flower, when it should immediately be ploughed up. The ground will be found greatly recruited by this crop, which has taken nothing from it and has added much by the dung and urine of the sheep. Whatever be the succeeding crop, it cannot fail to be productive; and if the land is not clean, the farmer must not have neglected the double opportunity of destroying weeds in the preceding summer and in the early part of spring. If the rape is fed off in time, it may be succeeded by barley or oats with clover or grass seeds, or potatoes, if the soil is not too wet. Thus, no crop will be lost, and the rape will have been a clear addition to the produce of the land. Any crop which is taken off the land in a green state, especially if it be fed off with sheep, may be repeated, without risk of failure, provided the land be properly tilled; but where cole or rape have produced seed, they cannot be profitably sown in less than five or six years after on the same land.

When the oil has been pressed out from the seed, the residue (which contains a portion of starch and mucilage not changed into oil) and the husk of the seed form a hard cake known by the name of rape-cake. This has been long used on the Continent, and has lately in this country been used, to feed cows and pigs with, as we use the linseed-cakes: but it is also much used as a rich manure, and for this purpose it is imported in large quantities. When rape-cake is ground to a powder and drilled with the seed on poor light lands, it supplies nourishment to the young plants, and greatly accelerates their growth; but if it be added in a large proportion in immediate contact with the seed, on heavy impervious soils, it often undergoes the putrid fermentation, which it communicates to the seed sown, and, instead of nourishing, destroys it. In this case it is useful to mix it with some dry porous earth or with ashes, which will prevent the too rapid decomposition. Dissolved in water and mixed with urine, it forms one of the most efficacious of artificial liquid manures. Hence it is probable that the most advantageous mode of using it on the land, after it has been dissolved in the urine-tank, is to apply it by means of a water-cart to the rows where the seed has been already drilled, or some time before it is put in. Where flax is to be sown, this mixture applied a few days before the seed is sown, so as to allow it to sink into the soil, is considered in Flanders as next in value to the emptyings of privies, which with them hold the first rank, for producing fine crops of flax. When a crop appears sickly, and not growing as it should do, owing to poverty in the soil, a top-dressing of rape-cake dissolved in water, if no urine is at hand, will in general excite the powers of vegetation; and it is highly probable that it may greatly assist the effects of saltpetre or of nitrate of soda, where these salts are applied. The cultivation of rape or cole for spring food cannot be too strongly recommended to the farmers of heavy clay soils.

RAPE-SEED. The *Brassica napus*, the plant which produces the rape-seed, and which is of the cabbage tribe, is cultivated like Cole, or Colza (*Brassica napus sativa*), for the sake of its seeds, from which oil is extracted by grinding and pressure. It is also extensively cultivated in England for the succulent food which its thick and fleshy stem and leaves supply to sheep when other fodder is scarce. The mode of cultivation of the colza and rape for seed is nearly the same. The colza takes a longer time to come to maturity, and produces more seed. The rape grows on less fertile soils, and may be sown in spring as well as in autumn. Both are hardy, and resist the winter's frost.

The rape seed imported in the years 1857-8-9 averaged 283,000 qrs. per annum: it is admitted free of duty.

RAREFACTION is an augmentation of the intervals between the particles of aeriform fluids, so that the same number of particles are made to occupy a volume greater than that under which they were previously contained. The term is used in opposition to *condensation*, and in the same sense as *dilatation*, which last is applied both to fluids and solids. Rarefaction or dilatation is caused by a repulsive power existing either in the particles of bodies or in those of the caloric between them, by which power the particles are made to recede from one another when not prevented by some external resistance. [ATTRACTION.]

The experiments of Lavoisier and Laplace have shown that, between the temperatures of freezing and of boiling water, the dilatations of all metals and of the fluids called non-elastic are constantly proportional to the increments of temperature; but beyond the temperature of boiling water the experiments of Dulong and Petit indicate that the dilatations increase in a higher ratio. A remarkable circumstance is observed in the state of water when near congelation. On being cooled to a temperature of about 38°·8 of Fahr., its volume remains stationary through a small range, and in this state water seems to have attained its *maximum of density*; for, on continuing the cooling process, the water begins to expand, and it continues to do so until it is converted into ice. In fact, just before water freezes it occupies a space as great as it did at 48°. If water at 39°·2 be taken as 1, at 32° its density = 0·99988.

From the experiments of M. Gay-Lussac and Dr. Dalton it has been ascertained that, under equal external pressures, the rarefactions of all dry gases and of the aeriform substances produced by the evaporation of liquids are equal at equal temperatures, between the points of freezing and boiling water, and that they vary in volume proportionally to the increments of heat expressed by the expansions of mercury in the thermometer. [AIR; HEAT; GAS; PNEUMATICS.]

The density or closeness of the aerial particles in any given portion of the atmosphere depends on the pressure or weight of the column of air above the given point; and by the law of Boyle or Mariotte, whatever be the temperature, provided it be constant, the density is proportional to the pressure; or, conversely, the rarefaction is inversely proportional to the pressure. It has been proved [PNEUMATICS] that the densities of the strata of air decrease upwards in a geometrical progression when the altitudes of the strata increase by equal increments; and this is equivalent to saying that the rarefactions of the air at such altitudes increase in a geometrical progression. Now if A be any point on the surface of the earth, and C any point above it, the formula AC (in fathoms) $= 10670 \times \log. \frac{\textit{density at } A}{\textit{density at } C}$ [PNEUMATICS], will afford the means of computing the rarefaction of the air at any point C, when its height above A is given. But if the density at A be considered as unity (the temperature being = 55°) the equation may be transformed into

$$\frac{AC}{10670}\left(= \log. \frac{1}{\textit{density at } C}\right) = \log. \textit{rarefaction at } C,$$

in which, substituting for AC any given value in fathoms, the rarefaction may be found. For example, let $AC = 3212$ fathoms (3·65 miles); then the second member of the equation will become ·30103 (= log. 2), which shows that at the height of about 3⅔ miles the rarefaction of the atmosphere is twice as great as at the surface of the earth; and by forming the progression of heights—

0 , 3·65 , 7·3 , 14·6, &c. in miles,

we have for the corresponding rarefactions—

1 , 2 , 4 , 8, &c.

For the rarefaction of the air in an air-pump, after any number of strokes of the piston, see AIR-PUMP.

The limits to which rarefaction may be carried are unknown, but the experiments of Mr. Boyle and others have proved that, by simply removing the external pressure, air may be so rarified that a given volume of the same density as at the surface of the earth will occupy a volume more than 13,000 times as great. It has been however discovered that at very high degrees of rarefaction the elasticity of the air decreases in a higher ratio than the density; and this may serve to prove that rarefaction cannot take place to an infinite extent. [ATMOSPHERE.]

RASP. [FILE MANUFACTURE.]

RASPBERRY. The species from which the cultivated varieties of this fruit have been derived is the *Rubus Idæus*, a native of Britain and also of various other parts of Europe. The wide dispersion of the species is easily accounted for from the fact of its seeds resisting the powers of digestion in an eminent degree.

For a selection, the following varieties may be enumerated:—Red Antwerp, Yellow Antwerp, Barnet, Double Bearing, and Wilmot's early Red.

The best soil for raspberries is a light rich loam. They will thrive well in sandy peat, provided it is not too dry. In all cases the ground for a plantation should be well trenched and manured previous to planting. The plants from suckers, of which there are generally abundance, should be planted in rows five or six feet apart, and four feet from plant to plant in the row. When planted they should be cut to within six inches of the ground; for although this is not absolutely essential, yet by so doing the shoots for the following season are greatly strengthened.

Pruning should be performed in autumn. It consists in first clearing off all dead portions, and retaining only from four to six of the strongest summer shoots of each plant, which should be shortened according to their strength, generally at a bend, which indicates where the shoot becomes weak, near the extremity. In the following summer the shoots just mentioned bear the fruit, whilst others spring up at their base for a succession; and in all cases succession shoots should be disposed so as neither to crowd the fruiting portion nor each other. Stakes should be driven for the support of the plants, to which they should be loosely bound.

The ground of a raspberry plantation should be kept loose and supplied with well-rotted manure, but in so doing a fork should be used in preference to a spade, in order to preserve the roots as much as possible, and the roots should not be at all disturbed after active vegetation takes place in spring. Notwithstanding the best management in these respects, it becomes adviseable to make a new plantation in fresh soil after four or five years; for the roots diffuse themselves so thoroughly in every portion of the soil near the stools, that it soon becomes exhausted.

The fruit of the raspberry is extensively used in a variety of ways, both by the cook and the confectioner, and also in the preparation of cordial spirituous liquors.

RATAFIA is a liqueur prepared by flavouring sweetened spirit with various kinds of fruit. There are many varieties, generally named after the fruit which is employed: *Ratafia de Cassio* has cherries; *Ratafia de Curaçoa* has the peels of Portugal oranges; *Ratafia d' Angelique* has Angelica seeds; *Ratafia d'Anis* has aniseed; and so on. There are ratafias not only of fruits but of seeds, berries, flowers, balsams, and other vegetable products. There are ratafias, for instance, of cherries, quinces, raspberry, juniper, walnuts, peach and apricot kernels, coffee, cocoa, clovepinks, Seville orange peel, orange flowers, violets, Tolu balsam, &c. All these ratafias have spice and sugar added to them. The French liqueurists are skilled in this as in most other branches of delicate distillation and making of essences. Many English processes of this kind come under the name of *rectifying*, as described under DISTILLERY.

RATE, an assessment levied upon property. Rates are of various kinds, and are denominated with reference to the objects to which they are applied.

Church-rates are payable by the parishioners and occupiers of the land within a parish, for the purpose of repairing, maintaining, and restoring the body of the church and the belfry, the churchyard fence, the bells, seats, and ornaments, and of defraying the expenses attending the service of the church. The duty of repairing and rebuilding the chancel devolves on the rector, or vicar, or both together, in proportion to their benefice, where there are both in the same church. But by custom the parishioners may be liable to repair the chancel; and in London there is a general custom to that effect. Church-rate exists in England by virtue of the common law; nothing is known as to its commencement or introduction.

In the early church there appears to have been a division of the tithes—either tripartite, one portion to the clergy, one to repairs of the church, and one to the poor; or quadripartite, one to the bishop, the other three to the clergy, the church, and the poor. At that time the bishop resided at the cathedral church, together with his clergy, and on him devolved the duty of repairing the church, caring for the poor, and supplying ecclesiastical ministry. It was then the duty of every Christian man to pay to the bishop not only the decimæ, or tithes, but also the ecclesiæ census, church-scot, and the nummus eleemosynarius (alms money). The object to which church-scot was devoted is not known; but church-rates, or something equivalent, certainly appear to have been in existence as a payment by the laity, independent of tithes, in the time of Canute, whose 63rd law, "de fano reficiendo," states that all persons ought of right to contribute to the repair of churches.

Church-rates are imposed by the parishioners themselves at a meeting summoned by the churchwardens for that purpose, and a mandamus is grantable to compel such meeting to be held. If the parish fail to meet, the churchwardens may impose a rate, but if the meeting should assemble, it rests with the parishioners themselves to determine the amount of the rate; and they have authority to negative the imposition of a rate altogether; the only mode of compelling them to impose a rate being by ecclesiastical censures and laying the parish under interdict. The existing poor-rate of the parish is generally taken as the criterion for the imposition of the church-rate. All property in the parish is liable except the glebe-land of that parish and the possessions of the crown. The ecclesiastical courts have the exclusive authority of deciding on the validity of a rate, and the liability of a party to pay it; but a rate-payer cannot by an original proceeding in those courts raise objections to a rate for the purpose of quashing it altogether. If he wishes to dispute it, he ought to attend at the vestry, and there state his objections; if they are not removed, he may enter a caveat against the confirmation of the rate, or refuse to pay his assessment. In the latter case, if proceeded against in the ecclesiastical court, he may in his defence show either that the rate is generally invalid, or that he is unfairly assessed. The consequence of entering a caveat is an appeal to the ecclesiastical judge, who will see that right is done. Previously to 53 Geo. III., c. 127, the only mode of recovering church-rates from parties refusing to pay was by suit in the ecclesiastical court for subtraction of rate. By that statute, where the sum to be recovered is under 10*l.*, and there is no question as to the validity of the rate, or the liability of the party assessed, any justice of the county where the church is situated may, on complaint of the churchwarden, inquire into the merits of the case, and order the payment. Against his decision there is an appeal to the quarter-sessions. As to other rates, see SEWERS; SHIRE; WAY.

(Lyndwood; John de Athon: Selden's *History of Tithes;* Gibson's *Codex;* Burn's *Ecclesiastical Law;* Rogers's *Ecclesiastical Law*, 1840.)

RATIO. One of the most frequent mathematical terms has no other name in our language than a Latin word which is but a bad translation from the Greek of Euclid. The older English writers introduced the word *reason*, as a translation of ratio, which completed the confusion; for it is easier to attach any meaning we please to a word in a dead language than to the literal translation of it in our own.

The word ratio is the translation of *λόγος*, as used in the third definition of the fifth book of Euclid, which is *Λόγος ἐστὶ δύο μεγεθῶν ὁμογενῶν ἡ κατὰ πηλικότητα πρὸς ἄλληλα ποιὰ σχέσις.* This has been translated by English writers, "Ratio is a mutual habitude of two magnitudes of the same kind with respect to quantity." By Gregory, in his translation which accompanies the Greek, "Ratio est duarum magnitudinum ejusdem generis secundum *quantuplicitatem* mutua quædam habitudo."

The common translation is unmeaning; and it will be worth while to offer some remarks on the probable meaning of Euclid. In the first place, let it be observed that he never attempts this vague sort of definition except when, dealing with a well-known term of common life, he wishes to bring it into geometry with something like an expressed meaning, which may aid the conception of the thing, even though it does not furnish a perfect criterion. Thus, when in speaking of a straight line, he says that it is the line which lies evenly (*ἐξίσου κεῖται*) between its extreme points, he merely calls the reader's attention to the well known term *εὐθεῖα γραμμή*, tries how far he can present the conception which accompanies it in other words, and trusts for the correct use of the term to the axioms which the universal conception of a straight line makes self-evident. Let us suppose him doing the same thing here, and we shall find that the definition before us, considered with reference to the place it is in, and the subsequent purpose which it serves, is as clear as the translation of it is confused.

The term *λόγος* contains (*λεγ, λογ*), a root the original meaning of which seems to have contained the idea of collection or bringing together. It is certain however that the secondary sense which it obtained in common usage was that of speaking; so that the first sense in which *λόγος* appears in writings is that of speech. Subsequently, speech being the distinctive character of reasoning beings, and their mode of communication, the word was applied to every sort of communication, not only with reference to the mode of communication, but also to its subject; thus explanation, defence, apology, teaching, assignment of cause or reason, &c., are among the recognised uses of the word. The Latin translators have taken the geometrical word as being properly translated by *ratio*, a word which may very well signify the technical meaning of *λόγος*, but has no reference to its primary meaning. For ratio, in its primitive sense, means rather computation or reckoning than reason.

But what has speech to do with the sense of ratio in geometry? Robert Recorde answers this question [NUMERATION], when he reduces his pupil to silence by forbidding him the use of number, and asking him questions. Numbers are but certain ratios, and ratio is a generalised idea of number. Our gift of speech with reference to magnitudes would be altogether annihilated if we did not consider a certain habitude or mode of existence which they have, or more correctly a certain conception of our own, which always accompanies the presence of two magnitudes, and prompts us to inquire how many times one is contained in the other. A foot being known, speech can carry a correct knowledge of other lengths all over the world; but let it be attempted to describe a foot in words without reference *κατὰ πηλικότητα* to some other magnitude, and all the powers of language utterly fail. We conceive then that in this definition Euclid simply conveys the fact that the mode of expressing quantity in terms of quantity, is entirely based upon the notion of *quantuplicity*, or that relation of which we take cognizance when we find how many times one is contained in the other.

The word *πηλικότης* has been translated "quantity," by many editors, which makes nonsense of the whole; for magnitude has hardly a different meaning from quantity, and a relation of magnitudes with respect to quantity may give clear ideas to those who want a word to convey a notion of architecture with respect to building, or of battles with respect to fighting; and to no others. Wallis, we believe, restored the true meaning of the word, and was followed by Gregory, as seen above: and Euclid himself, or some very old commentator, in another place, shows in what sense he used it. In the fifth definition of the sixth book (omitted by many editors), he says that a ratio is compounded of two other ratios when the *πηλικότητες* of the latter *multiplied* (*πολλαπλασιασθεῖσαι*) together, make the former. Now, this would be unmeaning if the Greek word meant simply quantities, unless they were quantities represented by numbers (though Gregory has here forgotten his own previous correction, and writes quantitas instead of quantuplicitas). The lexicographers generally give "quantitas;" but they are not adepts in the mathematical use of terms implying relations of magnitude.

The first and rough notion of ratio being thus given, we may find a synonyme for the word in the more intelligible term *relative magnitude.* Six feet, though greater than three feet, is, relatively to four feet, a less magnitude than three feet is, relatively to one foot: the number of times which six feet contains four feet is less than the number of times which three feet contains one foot. The relative magnitude of six to four is less than the relative magnitude of three to one; or the ratio of six to four is less than the ratio of three to one.

Given two magnitudes, how are we to find the means of expressing the first in terms of the second? Euclid answers this question, when it can be answered, in the tenth book, by giving the rule for finding the greatest common measure of two magnitudes, in which he employs a process exactly the same as that of the arithmetical rule in common use. Of two magnitudes which are multiples of the same third magnitude, each is a definite arithmetical fraction of the other.

But it may happen that the magnitudes have no common measure [INCOMMENSURABLE], in which case the means of expression would fail. We can describe the diagonal of a square as a part of a certain figure, and the description is perfect; but if we attempted a description *secundum quantuplicitatem*, we should never succeed; for no possible line exists of which it can be said that the diagonal of a square and its side both contain that line exactly. Such quantities are called by Euclid *ἄλογα*, irrational, or having no ratio; and in the primitive meaning of the term this is correct, for there is no quantuplicitative mode of expressing one by the other. But the term ratio, both in Euclid and all other writers, immediately acquires another sense; and it is this new sense in which we proceed to speak of ratio. Since the relative magnitude of two quantities is always shown by the quantuplicitative mode of expression, when that is possible, and since proportional quantities (pairs which have the same relative magnitude) are pairs which have the same mode (if possible) of expression by means of each other; in all such cases sameness of relative magnitude leads to sameness of mode of expression; or proportion is sameness of ratios (in the primitive sense). But sameness of relative magnitude may exist where quantuplicitative expression is impossible; thus the diagonal of a larger square is the same compared with its side as the diagonal of a smaller square compared with *its* side. It is an easy transition to speak of sameness of ratio even in this case; that is, to use the term ratio in the sense of relative magnitude, that word having originally only a reference to the mode of expressing relative magnitude, in cases which allow of a particular mode of expression. The word irrational does not make any corresponding change, but continues to have its primitive meaning, namely, incapable of quantuplicitative expression. And it is worth noting that this of itself shows that the original meaning of *λόγος* referred to expression, not to the thing expressed; for *ἄλογα* (not having a ratio) would have been absurd as applied to incommensurable quantities, if the primitive mathematical meaning of the first word had coincided with its modern one.

The idea of relative magnitude is one which strikes us in all cases in which we compare the parts of an original with the corresponding parts of any model or imitation. It does not closely connect itself with any mode of expression or measurement: if a part of the model were only in a slight degree too large or too small, the detection of the error might require a formal measurement, but anything which is very much out would be rejected by one glance of the eye. Let us suppose now that the formal measurement is attempted. The first and simplest notions of relative magnitude are gained from repetition; and the ideas of two, three, four, &c., originally used in their simple cumulative sense, soon become the representatives of those simple relative magnitudes which are suggested by pairs in which one is quantuple of the other. The next step is to those magnitudes in which neither is quantuple of the other, but both are quantuple of a third: from which we learn how, admitting aliquot parts, to extend the mode of expression. Thus, of the magnitudes 10 R and 7 R, we see that every relation of quantuplicity can be derived from the simple numbers 10 and 7: the first number is $1\frac{3}{7}$ of the second, a mode of expression which equally applies to the magnitudes 10 R and 7 R.

Let D and S be two incommensurable magnitudes: how are we to describe their relative magnitudes? That they have a definite relation is certain; suppose, for precision, that S is the side of a square, and D its diagonal; any alteration of D, or any error in D, S being given, would make the figure cease to be a square. There are many mathematical notions in which accuracy is not attainable in finite terms, but is the limit towards which we approach when number or magnitude, as the case may be, is increased or diminished without limit. In the present case the expression of ratio or relative magnitude, which is not accurately attainable by one or more relations, can be continually amended by adding one or more relations, until the inaccuracy of the mode of expression is rendered as small as we please; in such a case, accuracy must be imagined to reside in the supposition of an infinite number of given, or at least of attainable, relations.

To explain our meaning, suppose that the person whom we address is altogether ignorant of the relative magnitude of the diagonal D and the side S. He asks for a relation, and knowing the mode of dealing with the ratios of commensurables, naturally desires to know how many diagonals make an exact number of sides. If we could answer this question, if for instance we could say that 100 diagonals make 142 sides exactly, the question would be settled: for an arithmetical rule would always deduce the diagonal when the side is given. But we are obliged to reply, that no number of diagonals whatsoever will make an exact number of sides. He then asks how he is to form a perfect conception of the diagonal; we answer by placing two equal sides at right angles to one another, and joining the extremities. This, he replies, and properly, is not a mode of finding the relative magnitude, which is something connected with magnitudes only, and that the permission given by Euclid to join two given or determined points is not any real determination of the included length. We then tell him that it is at his pleasure to name a fraction of the side, and we can express the diagonal with an error not so great as that fraction; he names, say one-millionth of the side, and we give him the promised information in telling him that 1,000,000 of diagonals exceed 1,414,213 sides, but fall short of 1,414,214 sides. The consequence is, that the diagonal lies between 1·414213 and 1·414214 of the side: these differ from one another by one-millionth of the side, and the error of the diagonal is of course less. If he should ask how he is to carry this process yet further for himself, we give him the arithmetical symbol $\sqrt{2}$, and instruct him how to perform the arithmetical operation of approximating to its value. In this we show him how to find between what number of sides any number of diagonals lies; and in so doing we give the ratio of the diagonal to the side, so far as the nature of the case will admit of its expression.

The relative magnitude, then, of two magnitudes is given, when the place of any multiple whatsoever of the one among the multiples of the other can be found from the data. For example, we carry on the *multiple scale* of the side and diagonal of a square, in the power of extending which *ad infinitum* lies that of expressing the ratio, so far as expression is possible, and of absolutely comparing the ratio with others, in as accurate a manner as if expression had been perfect.

S, D, 2S, 2D, 3S, 4S, 3D, 5S, 4D, 6S, 7S, 5D, 8S, 6D, 9S, 7D, 10S, 11S,
8D, 12S, 9D, 13S, 14S, 10D, 15S, 11D, 16S, 12D, 17S, 18S, 13D,
19S, 14D, 20S, 21S, 15D, &c.

In this table we see, for instance, that 10 diagonals are more than 14 and less than 15 sides, and so on. The only doubt that can possibly remain may be thus expressed:—Is the preceding scale a property of the diagonal and of nothing else? May there not be a length so near to the diagonal that its multiples shall never fall out of the same intervals as those of the diagonal? Let K be a given quantity, no matter how small; we say that it is impossible that all the multiples of D + K can lie in the same places among the multiples of S as the multiples of D. Take *m* times both; then *m* (D + K) and *m*D differ by *m*K. Now however small K may be, it is possible to take *m* so great that *m*K shall exceed S, or any multiple of S previously named: whence the thing asserted is evident. The definition of the ratio of S to D lies, then, in this scale; or rather, whatever the definition may be, the mode of finding all relations between S and D lies in the formation of this scale so far as may be necessary for the purpose in hand. The definition of proportion is then contained in sameness of multiple scales; that is, D is to S as A to B, when any multiple whatever of D is contained between the same two multiples of S, that the same multiple of A is contained between those of B. We here come to the subject of PROPORTION, which the reader should now consult as a continuation of the present one.

It is well known that the word λόγος came to mean *fraction*, the expression of commensurable ratio. Fractional arithmetic was called *logistic* arithmetic even down to the 17th century. It is not so well known that this use of the word is as old as the time of Euclid. Aristotle gives, as his instances of discontinuous quantity, ἀριθμός καὶ λόγος, number and fraction. The logicians have always taken this to mean number *and speech*, some transcriber having interpolated a subsequent passage to this effect in the text of Aristotle. Plato tells us that the Egyptian Theuth invented ἀριθμόστε καὶ λογισμός, meaning, no doubt, integer and fractional reckoning. The idea implied in composition of ratio is very imperfectly treated in Euclid: and yet upon the correct understanding of it depends whether the boasted victory over the difficulties of incommensurables which the fifth book gives is real or imaginary.

In every matter connected with elementary geometry, confusion may and often does arise from mixing together criticisms of two different kinds; on Euclid as a writer, and on the subject as a matter of thought. To avoid such confusion in reference to composition of ratio, we shall begin with the consideration of what we find in Euclid, —not in Simson's Euclid, nor Playfair's Euclid—but in Euclid of Alexandria.

There is nothing on ratio compounded (συγκειμένος) of ratios in the fifth book; the word translated composition (σύνθεσις) refers to such a process as the formation of the ratio of A + B to B from that of A to B. But the definitions of duplicate, triplicate, &c. ratio, are laid down; which, as we shall see, are particular cases of compound ratio. These definitions are as follows:—if A, B, C, D, &c., be in continued proportion, so that as A to B, so B to C, C to D, and so on, then the ratio of A to C is called the duplicate ratio of that of A to B, the ratio of A to D is called the triplicate ratio of A to B, and so on.

In one proposition, and in one only, is the phrase composition of ratios used: in the 23rd of the sixth book, where it is said "Equiangular parallelograms have to one another the *ratio compounded of the sides.*" There is no definition (at least, it is now so supposed; here however we must refer to our next paragraph) given of the words in italics, and on looking into the demonstration of the proposition, we find we must assume, as a matter of phraseology merely, that of any three quantities of the same kind, K, L, M, we are to say the ratio of K to M is compounded of the ratios of K to L and of L to M. And further that if A be to B as K to L, and V to W as L to M, then the ratio K to M is said to be the ratio compounded of the ratios of A to B and of V to W. If there be anything more than mere phraseology in this, it must be because Euclid makes a tacit reference to some arithmetical system current in his time.

It is true that there is found in a great preponderance of manuscripts (in all, we believe) a definition of compound ratio. It is among the definitions of the sixth book, and literally translated* is as follows:—"A ratio is said to be compounded of ratios, when the πηλικότητες of the ratios multiplied together make a certain [ratio]." On the word left untranslated (which, we believe, must be translated by *quantuplicities*), we refer to what precedes and to what follows. This definition is admitted into the editions of Basel and Oxford, and into Briggs's edition of the six books. Peyrard has omitted it in the Paris edition, because, in his celebrated Vatican manuscript, it is not in the text, but has been added at the side. The Berlin editor admits it in parentheses as a disputable passage. Set a scholar to make the text of Euclid from the ordinary mode of weighing the evidence of manuscripts, and there is no doubt this definition must appear as a part of the elements. Set a geometrical reasoner to settle the question by the internal evidence of the passage and its keeping with the rest of the book, and there is as little doubt that it would be rejected. The meaning of the passage is, apparently, that if two ratios be expressed numerically, as those of 7 to 4 and 6 to 11, the ratio compounded of those ratios is to be the ratio of 7 × 6 to 4 × 11; or possibly, that, expressing the above ratios as those of $\frac{7}{4}$ to 1, and $\frac{6}{11}$ to 1, the compounded ratio is that of $\frac{7}{4} \times \frac{6}{11}$ to 1.

In the early translations from the Arabic, the definition is omitted, and reference is made, in demonstrating vi. 23, to a note inserted among the definitions of the fifth book, which is very insufficient. But the phrase there is that the ratio of *f* to *h* is *produced* from those of *f* to *g* and *g* to *h*: and to the definitions of the seventh book several are added, one of which is, that in a series of numbers the ratio of the first to the last is produced from the successive ratios of each to the one following.

In many manuscripts there is a scholium preceding the sixth book, which August, the Berlin editor, though not admitting it into Euclid, thinks must be of high antiquity; in which we fully agree with him. It is to be found in the Basel edition, and in the notes to the Berlin. This scholium, while it gives confirmation to the preceding view (which hardly wants it), takes the same side on the meaning of the word πηλικότης as we have done. And we find that Wallis was the person who suggested to Gregory *quantuplicitas* instead of *quantitas* as the translation. See his discussion of this point at length in his English Algebra (1684), ch. 19 and 20; revised in his Latin Algebra (Works, vol. ii. ch. 19, 20), and again at p. 665 of the same volume, where there is a defence of this definition against Henry Savile, who (Prælect. in Eucl.) had considered it as a great defect. To the text of Euclid we have only further to say that this consent of Savile, Wallis, and Gregory, as to the genuineness of the definition in question, is of great weight. But with regard to the matter of the definition we agree entirely with Savile. The word πηλικότης needs definition quite as much as the phrase *composition of ratios* itself. This definition, it will be observed, either restricts the composition to ratios which are of commensurable magnitudes, or implies and assumes the multiplication of two interminable decimal fractions. An old scholiast on

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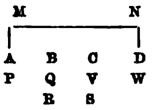
[*] *Λόγος ἐκ λόγων συγκεῖσθαι λέγεται ὅταν αἱ τῶν λόγων πηλικότητες ἐπ ἑαυτὰς πολλαπλασιασθεῖσαι ποιῶσί τινα.* The Scholium presently cited gives it with λόγον for τινα in one place, and πηλικότητα λόγου in another.

Euclid (cited from Dasypodius by Meibomius and Wallis) is of opinion that πηλικότης is used rather than the more natural word ποσότης, precisely that it may be understood in a wider sense, so as to include fractional and incommensurable ratios. That is, as Wallis expresses it, *how-much-fold* is used instead of *how-many-fold*, that *much* may suggest the idea of a part of a time (commensurable or not) where *many* would only suggest that of an integer. We cannot much admire this refinement; nor does it give any help: for the introduction of the idea of *incommensurability* numerically expressed, so as to be fit for arithmetical multiplication, would vitiate, or at least would transmute, Euclid's whole system of proportion.

But the oldest testimony, both to the existence of the definition, and the meaning of the disputed word, is Eutocius, in his commentary on book ii. prop. 5 (of Torelli, 4 of preceding editors). He here cites, expressly from the elements, the definition as given; and adds, as the explanation of πηλικότης, that it is the number which, by multiplication, turns the consequent into the antecedent. This number, he says, gives name to the ratio, and he cites Nicomachus and Heron as understanding it in the same way. But, he goes on to say, the word is more properly taken when this number is an integer.

Leaving now out of view what Euclid really did write, we shall proceed to consider the subject of composition of ratios, so as to supply what, on any supposition, must be acknowledged to be wanted in the elements. The notion of a ratio is easily and almost necessarily connected with the idea of alteration *in that ratio*. We cannot express a ratio without two magnitudes, the first of which, altered in the ratio given, becomes the second. If we want to alter in the ratio of P to Q, this is easily done when the quantity to be altered is P; for then the process is only writing Q instead of P. But if the quantity be A, then B must be found, so that A and B shall have the same ratio as P and Q.

If it be a numerical ratio which we consider, say that of 3 to 5, alteration of any number in that ratio implies that we change all its *threes* into *fives*, and any remaining fraction of three into the same fraction of five. Alteration of any magnitude, say a length, in that ratio implies that, choosing any length as a measure, we alter every three such lengths which the given magnitude contains into five, and every fraction of three into the same fraction of five. This amounts to changing the number or magnitude into five-thirds of what it was; and generally, alteration in the ratio of a to b (numbers) is nothing but multiplication by $\frac{b}{a}$



Take a magnitude A, alter it in the ratio of P to Q: say that it then becomes B; that is, A is to B as P to Q. Take the magnitude we left off with, B, alter it in the ratio of R to S, making it C. Take C, alter it in the ratio of V to W, making it D. Then at three processes, by three successive alterations dictated by given ratios, we have changed A into D, or have altered A in the ratio of A to D. Say that the ratio of A to D is more simply expressed by that of M to N. Then, if we begin with A, and alter it at once in the ratio of M to N, we change it into D, producing the same effect as if we had successively altered in the ratios of P to Q, R to S, and V to W. Hence the ratio of M to N is properly said to be compounded of the ratios of P to Q, R to S, and V to W: it dictates the alteration which will produce at once the effect of the three alterations prescribed by the three other ratios. In like manner, we say as to *addition*, that 10 is compounded of 6 and 4; for addition of 10 is equivalent to the addition of 6 and of 4. In multiplication we say that 24 is compounded of 6 and 4. And generally, the compound should be defined as that which produces the united effect of all the components, when both components and compound are used in the same way. Euclid, vi. 23, is now more than a mere addition to the phraseology of geometry. The parallelograms ABCD and EFGH [the reader may draw the figure for himself] being mutually equiangular, it tells us that if we take any magnitude and alter it in the ratio of AC to EG, and then alter the result in the ratio of AB to EF, the change thus made at two steps might be made in one by altering the original magnitude in the ratio of the area ABCD to the area EFGH.

This process applies equally to commensurable and incommensurable ratios; but in the former case of course the arithmetical substitute for composition of ratios is easy. We want to compound the ratios of m to n and of a to b, all four being integer numbers: it being known that every commensurable ratio is expressible by the ratio of two integer numbers. Take any magnitude P, and alter it in the ratio of m to n: it becomes n-$m$ths of P. Alter this in the ratio of a to b: we have then b-$a$ths of n-$m$ths of P, or bn-amths of P, which would also be obtained by altering P in the ratio of $a \times m$ to $b \times n$. Hence composition of numerical ratios is performed by multiplication of the antecedents for an antecedent and of the consequents for a consequent. The process then is merely equivalent to that of the multiplication of fractions. If $\frac{n}{m}$ and $\frac{b}{a}$ were called the quantuplicities (πηλικότητες) of the ratios, then the quantuplicity of the compound ratio is the product of the quantuplicities of the components, as in the definition (be it Euclid's or not) which is found in the manuscripts of the elements.

Duplicate ratio (διπλασίων λόγος) has been defined by Euclid in the manner hereinbefore given. But it is in fact the ratio arising from the composition of two equal ratios. Suppose we want to compound the ratio of P to Q with the ratio of P to Q. Take a magnitude to begin with, which may as well be P itself: alter it in the ratio of P to Q; it then becomes Q. Alter Q into R in the ratio of P to Q; that is, let R be a third proportional to P and Q. Then P is changed into R at these two steps, each involving an alteration in the ratio of P to Q: hence Euclid's duplicate ratio is the ratio compounded of two equal ratios; and, similarly, triplicate ratio (τριπλασίων) is that compounded of three equal ratios, and so on.

The subduplicate, subtriplicate, sesquiplicate, &c. ratios, which later geometers used, completed that language of multiplication and division applied to operations of powers and roots which finally suggested the idea of logarithms. [See also ADDITION OF RATIOS.]

The propositions requisite for the establishment of the direct use of compound ratio are contained in the fifth book. But in the inverse use there is a manifest hiatus in the converse part of vi. 22. It is supplied by a lemma added at the end of the proposition; which is found in almost all the manuscripts (even in the Vatican manuscript, and Peyrard admits it accordingly). This is a pretty sure sign that Euclid did not give the lemma; for he never refers to anything which is to come after what he has in hand. Robert Simson omits this lemma, and so leaves the proposition undemonstrated. What is wanted is the following:—It is impossible that the same ratio should have two sub-duplicate ratios, or should be the duplicate ratio of two different ratios; or, if A be to B in the duplicate ratio of A to X, and also in the duplicate ratio of A to Y, then X and Y must be equal. If possible, let them be unequal; say that X is the greater:

A X B
A Y B

Then because X is greater than Y, the ratio of A to X is less than that of A to Y. But the ratio of A to X is that of X to B; and the ratio of A to Y is that of Y to B; therefore the ratio of X to B is less than that of Y to B. Therefore X is less than Y; but it is also greater, which is absurd. Consequently X and Y cannot be unequal, &c. By a continuation of this process it may easily be established that a given ratio can only be the triplicate of one ratio, only the quadruplicate of one, and so on.

It is unnecessary to say anything on the *decomposition* of ratios. Clear as it becomes in arithmetic, after a while, that every multiplication is a division and every division a multiplication, it is much clearer from the beginning, in this subject, that every composition is a decomposition, and every decomposition a composition. Suppose that P to Q is the ratio compounded of A to B and C to D, and we wish to return back again to the ratio of A to B. We must compound the ratio of P to Q with that of D to C; for it is easily made obvious that the ratios of C to D and D to C compounded give the ratio of a magnitude to itself, the ratio of equality, the use of which effects no alteration.

It is now easy to see that all the operations of algebra which spring from multiplication inclusive, must be represented in geometry by operations of composition, &c. Robert Simson, who, as we have seen, has left a demonstration of the sixth book absolutely unfinished, though "Theon or some unskilful commentator" had provided a lemma which supplied what was wanting, has thought it necessary to add some very complicated propositions on compound ratio at the end of the fifth book. If they were intended as illustrations of the great difficulty of rendering the most common propositions of algebra into geometrical language (and what else could have been meant it is hard to imagine) the algebraical equivalents should have been introduced. Take the proposition K, for instance, which it may safely be asserted no beginner ever fathomed. The following is an arithmetical case of it. If

$$\frac{a}{b}\cdot\frac{c}{d}\cdot\frac{e}{f}\cdot\frac{g}{h} = \frac{i}{k}\cdot\frac{l}{m}\cdot\frac{n}{o}$$

$$\text{And } \frac{a}{b}\cdot\frac{c}{d} = \frac{i}{k}\cdot\frac{l}{m}$$

$$\text{Then } \frac{e}{f}\cdot\frac{g}{h} = \frac{n}{o}$$

RATIONAL. A quantity, algebraic or arithmetical, is rational when it can be expressed without the use of the signs of evolution, such as those of the square root, cube root, &c. [IRRATIONAL.]

RATIONALISM is a system of theology, which system began to be developed in Germany during the latter half of the last century. It arose in a great degree as a re-action against the principles and the method of biblical criticism promulgated by Voltaire, Volney, and the French Encyclopædists. Kant led the way, and his system endeavoured to preserve a medium between infidelity and supernaturalism. He was followed, more or less adopting his system, by Semler, J. D.

Michaelis, and J. G. Eichhorn. They directed their attacks against the deists as well as against the orthodox divines, but they confined the application of the rationalistic principle chiefly to the books of the Old Testament. Semler's principal works in this department are, 'Apparatus ad liberalem Veteris Testamenti Interpretationem,' Halle, 1773; 'Abhandlung von der Untersuchung des Kanons,' 4 vols., Halle, 1771-75, compare Semler's 'Leben, von ihm selbst verfasst,' 2 vols., Halle, 1781-82. The principal works of Michaelis are 'Einleitung in die göttlichen Schriften des alten Bundes,' 2 vols., Göttingen, 1750; 'Mosaisches Recht,' 6 vols., Frankfurt, 1770-75. Eichhorn was by far the most important writer of the school; he laid down and carried out the new principles in his 'Allgemeine Bibliothek der biblischen Literatur,' 10 vols., Leipzig, 1788-1801; 'Einleitung in das Alte Testament,' of which there appeared, in 1824, at Göttingen, the fourth edition, in 5 vols.; 'Einleitung in das Neue Testament,' in 2 vols., and several other works.

Eichhorn, whom we may consider as the representative of the new school, previous to the time when Dr. Paulus began to occupy a prominent position in it, sets out from the principle that the early history of the Jews should be considered in the same light and treated in the same manner as the early history of every other nation; and that a direct interference of the deity in the early affairs of all nations must either be admitted or denied. The reasons which led him to consider the fact of such a direct interference inadmissible in the case of other nations, led him to deny it in the case of the Jews also. Rejecting the views of the deists as unphilosophical and incompatible with the character of early history in general, he proceeds to state that it is natural to all nations in their primitive ages to speak of a divine interference in their affairs, wherever their ignorance conceals from them the real causes of the things which fall within their experience.

It is this belief, according to Eichhorn, which gives a form to all their ideas and expressions. But we, who live in a far more advanced and enlightened age, have neither reason to suppose that any miracles actually took place, nor that any kind of imposition was practised: we have only to translate the expression of those early ages into the language of our own time. In the infancy of mankind everything of which no direct cause appeared was referred to the intervention of supernatural powers; and accordingly all elevated thoughts, great determinations, useful inventions and institutions, and particularly dreams, were considered as the effects of a direct interposition of the deity; extraordinary knowledge and skill were looked upon by the people as proofs of supernatural power and of an intercourse with beings of a higher order. Moreover, not only the people, but the wise and great, were themselves fully convinced that they were acting under the immediate influence and were enjoying the especial favour of the Deity. Taking these premises for granted, and at the same time admitting that the biblical books were written by contemporaries, Eichhorn thought that all the facts of the Mosaic history might be explained as natural occurrences, without supposing, with the deists, that the writer was an impostor. The temptation and the eating of the forbidden fruit, the histories of Noah, Abraham, and Moses, are thus stripped of their supposed allegorical dress and of those features which it is supposed that they have received from the imagination of the writer, and are explained as natural events. According to Eichhorn, Moses was nothing but a great and benevolent patriot, who, after having long entertained the idea of delivering his countrymen from foreign slavery, was suddenly reminded of his scheme in a dream, and believing this dream to be from the deity, he represented it as a summons from Jehovah. The burning and smoking of Mount Sinai, according to this system of exposition, were only the effect of a fire which Moses kindled on the Mount for the purpose of keeping up the excitement of his people; and a storm with lightning, which fortunately happened at the same time, was a useful aid to him. The shining of his face was nothing but the consequence of great heat and excitement, which the lawgiver as well as his people, not knowing the real cause of it, believed to be the effect of a direct interference of the deity.

This system of interpretation was, as we have observed, principally applied to the Old Testament, but the New Testament also contains passages which were too tempting to be passed over by the rationalists. It was at first chiefly the appearance of angels in the New Testament on which Eichhorn tried the rationalistic interpretation, and all passages of this kind ought, according to this critic, to be considered as figurative expressions or allegories: thus a happy chance is represented as a saving angel; an internal joy, as the salutation of an angel; and great calmness and peace of mind, as a comforting angel, &c.

The way being thus prepared, the number of rationalistic divines increased, and their influence became apparent in many other departments of knowledge. A Utilitarian school had at the same time acquired considerable power; and so far as it endeavoured to instruct the people in the so-called useful sciences, and to do away with everything which was deemed superstitious, it went hand in hand with and supported rationalism, which now began to be carried out in its whole extent with regard to the New as well as the Old Testament.

Among the works which gained the greatest popularity, we may mention K. F. Bahrdt, 'Briefe über die Bibel im Volkston,' 1782; Eck, 'Versuch über die Wundergeschichten des Neuen Testaments,' 1795; 'Die Wonder des Neuen Testaments in ihrer wahren Gestalt für ächte Christusverehrer,' 1799; 'Natürliche Geschichte des grossen Propheten von Nazaret,' 1800. The two last works, which were published anonymously, were written by Venturini. Most of these, and the numerous other works of the same tendency, were written in a popular style; and those of Bahrdt had often a coarse and vulgar tone. The philosophical systems of Hegel and Schelling had the same realistic tendency, though in a less popular form. But none of these writers equalled Dr. Paulus of Heidelberg, either in learning or ingenuity; and he it was who most completely developed the whole system of Rationalism. His principal works are—'Philologisch-kritischer und historischer Commentar über das Neue Testament,' 4 vols., Lübeck, 1800–1804 (this work was republished in 1830-33, in 3 vols., with numerous alterations and corrections, under the altered title of 'Exegetisches Handbuch über die drei ersten Evangelien'); 'Das Leben Jesu, als Grundlage zu einer reinen Geschichte des Urchristenthums,' 2 vols., Heidelberg, 1828. Paulus first insists upon the necessity of distinguishing between those passages of the Bible in which the writers simply state facts and those in which they give their own opinions of them. A fact, according to him, is that which the writers describe as having taken place within their own experience; an opinion, on the other hand, is the manner in which they interpret an occurrence and trace it to what they conceive to be its cause. But as these two elements are in most cases interwoven and mixed up with each other in the biblical writings, Paulus conceives it to be the chief object of the biblical critic to separate them, and to discover the genuine historic truth in the various disguises with which the opinions of the age and of the writer have surrounded it; and he thinks with Eichhorn, that this object may be accomplished if the critic transports himself as much as possible to the scene of the events, and supplies such accessory and explanatory circumstances as may have been neglected or overlooked by the reporter or eye-witness. Thus the New as well as the Old Testament is deprived of its divine character, and all supernatural interference in the affairs of the Hebrews and in the introduction and establishment of Christianity is denied. Christ is no longer the son of God, but a wise and virtuous man; his miracles are either acts of friendship and humanity, and manifestations of his skill in the healing art, or the effects of a happy chance. In short, the whole history of the Bible assumes an aspect totally different from that of the original records, and from that which their authors manifestly intended; in fact it becomes a romance without any foundation except the assertion of the Rationalist that things did actually happen thus and thus.

A reaction against the spirit of this school manifested itself during the first ten years of the present century. The dreadful ravages caused by the French Revolution created a general desire to restore or maintain the good old times by returning to the religious and political institutions of past times. But although this reaction was successful in other departments, it had very little effect in theology, as it manifested itself rather in passive and retired mysticism than in energetic efforts against the system of the Rationalists. A vigorous opposition however began in 1810, which was called forth by the publication of Reinhard's 'Geständnisse,' in which Rationalism and Supernaturalism were declared to be diametrically opposed and utterly irreconcilable with each other. This assertion was denied by other theologians, who endeavoured to reconcile the two schools. The contest which then commenced was carried on in a calm and philosophic spirit till 1817, when the centenary anniversary of the Reformation was celebrated in Germany, and the Supernaturalistic party, headed by Dr. Harms, of Kiel, endeavoured to make the question a practical one, and to draw to it the attention of the governments and of the whole German nation. The Rationalists were now universally decried as infidels, and as men who had forfeited all right to be called Christians; and innumerable works were written by the theologians of both parties to defend their opinions. The principal champions on the Supernaturalistic side, besides Harms, were Hengstenberg and Tholuck; on the side of the Rationalists, Gesenius, Wegscheider, Paulus, and Röhr. In these controversies, the rationalistic theory itself almost disappeared, and the question assumed the more general character, whether the Protestant church should allow freedom of thought or not. This turn of the question induced many of the moderate Supernaturalists, who could not sacrifice their liberty of conscience, to side with the Rationalists. Their wish, however, was merely to bring about some kind of a reconciliation, and not to allow the question to become a national one. Their opinion was that it should be kept strictly within scientific limits, and confined to the learned. Although willing to make concessions to the Rationalists on many points, they were anxious to prevent any practical innovations.

Each party, however, continued to maintain its tenets. One of the more important rationalistic works which appeared during this period was 'Was heisst glauben, und wer sind die Unglaübigen?' by David Schulz, 1830; while Neander and Schleiermacher took the opposite side with much learning and success.

Up to the year 1835 this second form of Rationalism had been applied only partially, and chiefly to portions of the Old Testament; but it was then carried out in its full extent with reference to the books of the New Testament, by Dr. David Frederick Strauss, in his 'Das Leben Jesu kritisch bearbeitet,' in 2 vols. The first edition appeared in 1835-36; a second was published in 1837, and a third in 1838. This work, the production of a man of great learning, profound reflection, and critical skill, called forth a host of polemical works, but the best efforts against it were made by the Supernaturalistic school. Rationalism in its first form seems to have received its death-blow from this work and the various controversial writings of Strauss and others, while the new school made rapid progress. The contest between it and the Supernaturalists was however, with few exceptions, conducted in a calm and purely philosophic manner. Both parties were honest enough to give way whenever any of their disputed points were proved to be untenable. This is manifest from the 'Life of Christ' published by Neander, and from the different editions of the work of Strauss.

Notwithstanding the wide breach between the two parties, approximations were made on both sides, so that the Supernaturalists as well as the Rationalists might each be divided into two parties. Some of the latter, such as Paulus, Wegscheider, Gesenius, Schulthess, Schulz, and others, continued to consider reason as their only guide in matters of religion, and rejected every supernatural revelation: others, the so-called Supernaturalistic Rationalists, admitted indeed a supernatural revelation, but considered reason as the only means of recognising and acknowledging it; they thus still allowed reason to be the supreme judge in matters of religion. To this class of Rationalists belong Bretschneider, Von Ammon, Böhme, Hase, Köster, and others. A similar division exists among the Supernaturalists.

The view which the Rationalists had taken of the Scriptures contained some elements which led to a new crisis in German theology. Some parts of the Scriptures, from which the Rationalists, with all their ingenuity, saw no hope of eliciting a genuine history, they had ventured to declare to be a mere legend, tradition, or mythus. This view was gradually applied to a great portion of the Old Testament, as in Bauer's 'Hebräische Mythologie,' Leipzig, 1802. The various and profound investigations into ancient profane history had led to similar results in other departments, and the hollowness of the Rationalist interpretation was either loudly proclaimed or tacitly acknowledged by all parties. The consequence was either a return to the Supernaturalistic view, or further progress in the path which had been opened by the Rationalists themselves. Those Rationalists who could not do the former now applied the principle, to which they had formerly recourse only in cases of extreme difficulty, to the whole body of the early and miraculous portions of the Scriptures, which they placed on the same footing with the early and fabulous stories of ancient Greece and Rome, and considered as a mythical history not written by eye-witnesses or contemporaries, and only recorded after it had been handed down by tradition through many generations. According to this view, all the events in the Bible are either natural events, such as occur in the history of other nations, and which must be examined according to the general principles of historical criticism, or they are of a miraculous and supernatural character, and must for this reason be rejected as not historical, like the fabulous accounts of ancient mythology. As the Rationalistic school directed its first attacks against the deists, so the mythical school, though diametrically opposed to the Supernaturalists, directed its main efforts against Rationalism. We must nevertheless consider this last school as essentially Rationalistic, or as a second form of Rationalism, in as far as, like Rationalism in its first form, it takes reason for its sole guide, and denies all supernatural revelation. The only difference is that it denies the Biblical records to be the works of eye-witnesses and contemporaries, and hence draws the conclusion that it is utterly impossible to elicit from those portions which are supposed to consist of mythical stories anything like a true and connected history.

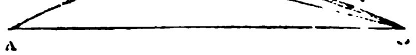
Rationalism in the German sense never made much way in England, being chiefly confined to a portion of the Unitarian sect. But of late years more recent principles of historical and philological evidences, with the incontestable facts established by geological and palæontological investigations, have led to closer though more reverent approaches to it from various quarters. The most remarkable is what is known as the new school of divines at Oxford, of whose views the fullest development is afforded by the works of the late Baden Powell and the Rev. B. Jowett; and the 'Essays and Reviews' issued by these gentlemen and the Rev. J. Temple, Dr. Williams, Rev. Mr. Wilson, Mr. Goodwin, and Rev. Mr. Pattison, in 1860. The more orthodox view of the question has not been wanting of numerous supporters.

Details of the various opinions of many of the writers mentioned in this article will be found under their respective names in the BIOG. DIV., and under MIRACLES there is given a list of foreign writers, nearly all of whom are purely rationalistic.

RATIOS, PRIME AND ULTIMATE. These terms were first introduced, at least in a system, by Newton, who preferred them to the terms suggested by his own method of fluxions. The first section of the Principia contains the development of their meaning, with various propositions enunciated in their language. In the articles LIMIT and INFINITE we have already had the same notions to consider, couched in different words; but when we remember that the only sure foundation of the differential calculus, that is, of all the higher part of mathematics, must rest upon these notions, it will be worth while to dwell a little upon Newton's form of expression, and his method of employing it. The notions in question actually form part of the knowledge of many persons who are not mathematicians, and all whose occupations lead them to any considerations connected with measurement, must in some degree possess and appeal to them.

All who understand the term ratio must see that the ratio of two quantities does not depend on their actual magnitudes. If one line be to another in the ratio of 3 to 7, the halves, thirds, fourths, &c. of the two lines will have the same ratio; and the subdivision into aliquot parts may be continued without limit; thus the hundred-millionth part of one line will be to the hundred-millionth part of the other as 3 to 7. Ratio then always exists, so long as there is magnitude; but if magnitude should cease to exist, and if both lines should vanish, no idea of ratio can be formed. If however the diminution take place by continual subdivision, this evanescence of magnitude never takes place; for into how many parts soever a line may be divided, each part is a length, still subdivisible for ever.

The consideration here introduced is not an easy one at first, for there is a degree of smallness which evades the senses, and reason must come to their assistance. This makes a great difficulty, for many who think themselves rational geometers are not aware how much of their ordinary perception of geometrical truth is the consequence of what they see, not of what they deduce. All magnitude is relative, so far as the notion of great or small is connected with it; we know this when we stop to think, but we do not easily take it along with us in our thoughts; there is nothing absolutely great or small, but we are continually making an absolute greatness out of magnitude which is great compared with our own bodies, and an absolute smallness of that which is in the same sense comparatively small.



Take A O, an arc of a circle, A_2O its half, A_3O its third part, A_4O its fourth part, and so on; let the chords A O, A_2O, A_3O, &c. be drawn. The points A_1, A_2, A_3, A_4, &c., constitute a series continually approaching to O in position, but never reaching it, for no aliquot part of A O is absolutely nothing. Now it can be shown that A_xO, the chord of (A_xO) the xth part of the arc, will be nearer to a ratio of equality with (A_xO) the greater x is taken, so that any approach to equality may be attained and passed by making x sufficiently great. The beginner's notion is, almost invariably, that two small quantities must be nearly equal, because they are small; and the fallacy under which they proceed is the following:—quantities which are nearly equal to the same are nearly equal to one another; small quantities are all nearly equal to nothing, therefore small quantities are nearly equal to one another. The mistake here lies partly in the use of *nothing* as if it were a quantity, having all the properties of quantity, partly in the supposition that quantities which differ little must be nearly equal. If by differing little be meant that the difference is trifling when compared with the quantities themselves, the notion is a good one: two microscopic animalcules are nearly equal when they differ by a small portion of an animalcule; but if they differ by the size of a gnat, though their absolute difference is still small, compared with our usual standards, the larger is immensely greater than the other. But if the just notion of nearly equal be adopted, it is wrong to say that the chord and arc are nearly equal on account of their smallness, since their small difference may possibly itself be larger than one of them. And as to using *nothing* as a quantity in the fallacious syllogism above given, it must be remembered that, with reference to possibility of subdivision, any quantity, however small, is as distant from nothing as any other quantity, however great, is from infinity.

Nevertheless, as may be rationally shown, the chord and arc are the more nearly equal the smaller they are. The conception of this proposition may be aided as follows:—however small a line may be, we may represent it by as great a number as we please, if we take the unit of measurement still smaller, and sufficiently smaller; now let the arc taken be the nth part of the radius; then if a unit be taken so small that the arc shall be represented by $24n^2$, the chord will be a fractional number extremely near to $24n^2 - 1$. Thus if the arc be one-thousandth of the radius, and a unit be taken to measure it which is its 24-thousandth part, so that the arc is 24,000, the chord will contain that unit a very small fraction more than 23,999 times. And if n be made still greater, the inequality will be made still less, being capable of being made less than a unit out of any number we may name, however great.

In the article LIMIT we should say that the limiting ratio of the arc and chord is unity; in INFINITE, that an infinitely small arc is equal to its chord. Newton's phrase was that the arc and chord are ultimately equal, or that their ultimate ratio is one of equality. He strives to guard this language as much as possible in the Scholium which terminates the first section, and from which we now quote.

"I have premised these lemmas, that I might avoid the tedium of long demonstration, with reductions *ad absurdum*, after the manner of the ancients. Demonstrations are shortened indeed by the method of indivisibles." [CAVALIERI, in BIOG. DIV.] "But since this hypothesis is somewhat difficult, and the method is not thought very geometrical, I have preferred to make what follows depend upon the ultimate sums and ratios of vanishing quantities. . . . . I do not wish to be understood as using indivisibles, but divisible vanishing quantities; not sums and ratios of determinate parts, but limits of sums and ratios. . . "It is objected that there is no ultimate proportion of vanishing quantities, because, before they have vanished the proportion is not ultimate, and after they have vanished there is no proportion. But by the same argument it could equally be contended, that there is no last velocity with which a body reaches the place where its motion stops; for before the body reaches its final position, it has not its last velocity, and when it reaches it, it has no velocity. And the answer is easy: by the last velocity I understand that which the body has, not before it reaches its last point and the motion stops, nor afterwards, but at the moment when it reaches, namely, that very velocity with which the body reaches its last position, and with which the motion ceases. And similarly, by the ultimate ratio of vanishing quantities, is to be understood the ratio of the quantities not before they vanish, nor after they vanish, but with which they vanish. Similarly the prime ratio of nascent quantities is the ratio with which they begin their existence (ratio quacum nascuntur). And the prime and ultimate sum is that with which (whether increasing or diminishing) they begin and cease. . . . It may also be contended, that if the ultimate ratios of vanishing quantities be given, the ultimate magnitudes will be given; and thus that every magnitude will consist of indivisible parts. . . . . But this objection proceeds on a false hypothesis. The ultimate ratios with which quantities vanish are not really the ratios of ultimate quantities, but the limits to which the ratios of quantities diminishing without limit perpetually approach, and which limits may be attained within any given difference, but can never be passed, nor even actually attained, before the quantities are diminished in infinitum. The thing will be more clearly understood by speaking of infinitely great quantities. If two quantities with a given difference be increased in infinitum, the ultimate ratio will be given, that is to say, a ratio of equality, but the ultimate or greatest quantities of which this is the ratio will not therefore be given. In what follows therefore, if ever, thinking of making things more easily conceivable, I should talk of the last possible quantities, or of vanishing or ultimate quantities, do not understand thereby quantities of determinate magnitude, but think always of quantities diminishing without limit."

This notion, whether of limiting ratios, of ultimate ratios, or of the ratios of infinitely small quantities, is a real and positive conception of our minds, but one of which, put it into what language we may, the mode of expression is liable to some objection. The ultimate magnitudes of the senses are not those of the understanding, but all our terms connected with the latter are derived from habits of thought matured by aid of the former. The ultimate arc of a curve which the eyes perceive is, to those eyes, really straight, all curvature being imperceptible. Indeed sensible straightness begins long before length vanishes. Continued reflection only will clear away the approximate truths of the senses, and enable the student to see how the ultimate truths of the theory of limits are to be established.

The study of the theory of ultimate ratios, as given by Newton, is desirable on several grounds. The mere acquisition of the language is a benefit; for subject as all terms in which the propositions can be expressed are to misapprehension, it frequently happens that the associations which one kind of language suggests are corrective of errors which another language has allowed, or even favoured. No student can be sure that his ideas on the subject are sound until, comparing together any proposition (as in DIFFERENTIAL CALCULUS) expressed by means of infinitesimals, limits, and ultimate ratios, the same proposition in the three different ways, he feels a perfect coincidence of meaning between the three statements, and that each expresses as much as, and no more than, the others. Again, the consideration of ultimate ratios puts vividly before the mind of the student who is used to the algebraical methods, a picture of the truth which is meant to be stated, and prevents his resting upon the abstract symbols of the Differential Calculus. For want of such an accompaniment to the latter study, many have found it repulsive, more, unintelligible, at least for a long time, and some have even never arrived at any rational comprehension of its meaning.

RATTANS, or **CANES**, though comparatively unimportant, form a considerable article of commerce in the East. They consist of a kind of palm-reed, which climb over and around the trees in many large and dense forests of the Malayan peninsula and the Eastern Archipelago. They are separated from the trees by a kind of cleaver, and are close, long, well glazed, bright yellow, slender, and supple. They are split into strips and bound into bundles of 100 each. Chinese merchants buy them in Borneo at the extremely low price of about 4*d*. per bundle, and sell them largely for use in China. English merchants can obtain about 20*d*. per bundle for them at Calcutta. England alone imports as many as 10,000,000 rattans in a year, chiefly for use in chair-bottoms and umbrella-frames.

RAVELIN, a work constructed beyond the main ditch of a fortress, and in front of the curtain between two bastions. It usually consists of two lines of rampart, which meet in a salient angle on a line drawn perpendicular to and bisecting the curtain; and its form on the ground-plan may be seen at Q, *Fig.* 1, BASTION, and at Q Q, FORTIFICATION. Its profile, or the figure of a vertical section of its rampart, is similar to that of the enceinte. [BASTION, *Fig.* 2.]

The ravelin was probably first constructed in the place of the more ancient barbacan by the Italian engineers of the 16th century, when, on account of the general employment of cannon in sieges, the ancient towers and walls of masonry were either replaced or covered by ramparts of earth. Its original name, *rivellino*, indicates a derivation from *vegliare*, "to watch;" and both by Maggi (1584) and Errard (1594), rivellino, or ravelin, and bastion, are used as the names of a work beyond the walls of a fortified place. In some cases the rivellino appears to have been merely a parapet of earth covering a small place of arms in which were stationed the men appointed to guard the head of the bridge leading from a postern to the counterscarp of the ditch; and a work of this kind, of a semicircular form, still exists on the exterior of the ditch on one side of Carisbrooke Castle. It can scarcely be doubted that a semicircular form was very frequently adopted for such parapets, and this circumstance may have given rise to the name of demi-lune, or half-moon, by which, even now, the ravelin is often designated. It ought to be observed however that Errard and other writers of that age apply the word ravelin to a work placed immediately in front of the salient angle of a bastion, where the counterscarp of the ditch (which is there in the form of a segment of a circle) constitutes the gorge of the work, and that the name of half-moon may, on this account have been applied to the work, though its faces were retilinear. A work thus situated is now invariably called a counterguard; and the term ravelin, or demi-lune, is confined to the principal outwork in front of the curtain.

When the necessity of increasing the strength of fortresses by means of works beyond the enceinte, in consequence of the superior means employed in the attack, was strongly felt, the ravelin was made more capacious, and was provided with artillery; and, in order to prevent it from being taken by surprise, its ditch was enlarged, and the covered-way was continued on the exterior of the latter along both the faces of the work. Before the middle of the 17th century the ravelins were so small, that the exterior lines (the cordons) of their faces, if produced towards the rear, fell upon the curtain of the enceinte, and the lengths of the faces did not exceed 30 yards. Count Pagan then enlarged the works so that the produced faces fell at the shoulders of the bastions; but Vauban apparently, in what has since been denominated his first system, made the faces of the ravelins about 110 yards long, and directed them towards points on the faces of the bastions at 10 yards from the shoulders [Q, *Fig.* 1, BASTION]. The magnitude of the work was then such as to render it capable of making a good defence: it covered the curtain and flanks of the enceinte, so that the enemy could not demolish their parapets by means of artillery in his distant batteries; and one being placed on each front of the fortress, every two afforded not only a crossing fire on the approaches of the enemy towards the intermediate bastion, but they seriously impeded the formation of the counter-batteries on the crest of the glacis.

It was subsequently perceived that great advantages would arise if the faces of the ravelins were made still longer, and if they were directed to points at a greater distance from the shoulders of the bastions: by the first, as a reverse fire, as it is called, might be directed from the angle of the work upon the enemy's lodgments on the glacis before the bastions, he was compelled to take and make lodgments in two contiguous ravelins before he could proceed to attack the bastion; and by the other, the power of breaching the shoulders of the bastions, that is, in rear of the most advantageous position for a retrenchment, by means of a battery on the glacis, before the salient angle of the ravelin, would be taken away from him. At Landau and other places, Vauban, without increasing the lengths of the faces of the ravelins, directed their exterior lines to points at 20 yards from the shoulders of the bastions; while at Neuf Brisac he not only made the lengths of the faces about 120 yards, but he directed them to points at 30 yards from the shoulders. It should be observed however that at about 20 yards from the counterscarp of the main ditch he changed the directions of the faces, and made the portion between this point and the ditch nearly perpendicular to a line joining the salient angles of the collateral bastions, as in the work Y, FORTIFICATION; by which means the second advantage, above mentioned, was lost. The intention of Vauban in thus giving flanks to the ravelin was that he might obtain a fire from thence on any breach formed in the face of the bastion, and that the difficulty of forming a lodgment on the glacis in front of the bastion might be increased so much as to oblige the enemy to take the ravelin before he could execute such lodgment: but experience has shown that this is not the fact; for the flanks, as he has formed them at Neuf Brisac, having no work to cover their prolongations, are enfiladed, and their guns dismounted, at an early period of the siege.

Cormontaingne (1736) greatly improved the ravelin by giving it the figure represented at Q Q, FORTIFICATION, making the length of each face about 130 yards, and directing that line to a point between 20 and 30 yards from the shoulders of the bastions. He reduced the terreplein, or space between its parapet and the counterscarp of the redout Y, to 27 feet, in order that the enemy might not find room on it to form batteries for the purpose of breaching the redout of the ravelin; and the faces being unbroken in direction, not only are the shoulders of the bastions covered, but the enemy is prevented from breaching any part between the shoulder and the retrenchment X. The gorge, or rear line, of the ravelin, instead of coinciding with the general direction of the counterscarp of the main ditch, is made parellel to the curtain of the place, in order to take away a part of the terreplein which would have been seen by the enemy from his counter-batteries on the glacis of the bastion. It appears that Cormontaingne wished to give the ravelins a greater length of face than that which has been mentioned, and that he was prevented from doing so through the opposition of his contemporaries. For the advantages to be derived from very salient ravelins, see FORTIFICATION.

The only change which has since been made in the position of the ravelin is that which was proposed by Bousmard (1803), and followed in the works executed by order of Napoleon about Alessandria (1807) by Chasseloup de Laubat. It consists in placing the work beyond the glacis of the enceinte, at the foot of which glacis its ditches terminate; the covered-way and glacis before the bastions being continued uninterruptedly along the exterior of the main ditch. It thus becomes impossible to breach the enciente by artillery placed anywhere on the glacis of the ravelin; and, when the direction of each face is broken, as that engineer recommended, the probability of the rampart being enfiladed is much diminished. It might perhaps be objected that the ravelin so detached is liable to be attacked at the gorge; but if the covered-way of the ravelin be made to join that of the collateral bastions, and if its flanks or those of the redout, are disposed so as to allow a fire of musketry to be kept up in the direction by which the enemy must approach the gorge, this danger may be obviated.

The relief of the ravelin, or its elevation above the level of the ground, should be two or three feet less than that of the enceinte, in order that the defenders of the curtain may be able to direct a plunging fire into the work when it is occupied by the enemy. But if in the interior of the ravelin there should be a redout, this last ought, for the same reason, to have less relief by two or three feet than the curtain; and then, in order to afford a plunging fire from the redout into the ravelin, the latter should be two or three feet lower than the former. It ought however to have a command of six or seven feet over the glacis in its front, that the fire of its artillery may not annoy the defenders on the banquette of its covered-way. Therefore, if the command of the enceinte over the ground is 18 feet, and that of the glacis is 7 feet, the differences between the heights of the enceinte and redout, and of the redout and ravelin, may be 2 feet successively.

RAY. [LIGHT.]

RE, in Music, the name given by the Italians and French to the second note of the diatonic scale, and generally throughout Europe to the second of the syllables used in SOLMIZATION.

REAL ESTATE. [PROPERTY.]

REALGAR. [ARSENIC, *Compounds of sulphur and arsenic.*]

REALISTS. [NOMINALISTS.]

REAPING (or cutting corn when it is ripe) is one of the most important operations of harvest. It requires many hands to accomplish it in proper time, so that the corn which is ready for the sickle may not be too ripe and shed, nor the fair weather be allowed to pass before all the corn is secured in barns or stacks. The labourers who are required all the year for the common purposes of husbandry seldom suffice for the harvest, especially on extensive farms, and recourse is usually had to the assistance of mechanics and artisans from the neighbouring towns and villages where the population is considerable, or labourers are induced by good wages to come from a distance. As the harvest is later in those parts of every country which have a more northern situation, or are higher above the level of the sea, bands of reapers from these come to assist in the harvest of those tracts whose produce is earlier. To encourage the annual return of so desirable assistants, every encouragement is given them, not only by wages, but also by food and drink, and amusements after the toil of the day. Thus the time of harvest is a time of rejoicing both to the labourers and the master.

The common reaping-hook, or sickle, with which the corn is usually cut, is one of the oldest instruments of husbandry; and the goddess Ceres was generally represented by the ancients with a sheaf of corn and sickle in her hand. In reaping with the sickle, a portion of the stems is collected with the left hand, and held fast; while the sickle in the right hand is inserted below the left, taking the stems in its semicircular blade, and cutting them through by drawing the sickle so as to act as a saw, for which purpose the edge is finely serrated in a direction from the point to the handle. The heads of the corn, with the upper part of the straw, are then laid on the ground in quantities which may readily be collected into a sheaf. Practice soon gives dexterity to the reaper; and he finds it more expeditious to cut small quantities in succession until he has filled his hand, than to attempt to cut through a large handful at once. Severe wounds are often inflicted on the fingers of the left hand by beginners, even to the loss of a finger; but this soon makes them cautious and expert. The division of labour is introduced with advantage amongst a band of reapers. A certain number cut the corn, while others follow to gather the sheaves; some only preparing the bands, and others tying them and setting up the sheaves into stooks or shocks, which usually consist of ten or twelve sheaves. The smaller the sheaves are, the less injury the corn sustains in a wet harvest; as the moisture in a thick sheaf does not so readily evaporate. Hence it is the interest of the farmer to see that the reapers do not make the sheaves too large. In many places there is a regular measure for the circumference of a sheaf, which should never exceed thirty inches. The bands are made by taking two small handfuls of the cut corn, and crossing them just below the ears into a knot. The sheaf is then pressed with the knee, and the band drawn tightly around it. The ends are twisted together like a rope, and inserted under the band, which effectually fastens it. This operation is soon learnt, and is done very rapidly. The sheaves should be so tied that there may be no danger of their falling loose when pitched into the cart or stacked, without being so tight as to prevent the moisture in the straw from evaporating. They should not be tied too near the ears, but rather nearer to the butt. The sheaves, when tied, are placed two and two on the butt-ends, with the ears leaning against each other: sometimes they are placed in a circle, all the ears being together, and the buts slanting outwards; a sheaf is then opened, by inserting the hand into the middle of the ears, and reversed over the tops of the preceding, forming a cone, and covering all the other ears, while it hangs down around them. In this position they will bear much rain without injury. It is a good practice to place the shocks across the furrows between the stitches or lands, so as to allow the air to circulate more freely around them. In this case four or five sheaves are placed in a row, leaning against as many in a parallel row; and two sheaves, being opened, are reversed over them to protect the ears. Whatever be the mode adopted in reaping the corn, the same kind of sheaves are formed, and set up in shocks.

Wherever the sickle is used for reaping, the straw is cut at a certain height from the ground, and the remainder forms a long stubble, which is usually mown at leisure after harvest, and carried into the yard for litter; but in the neighbourhood of large towns, where straw is sold at a good price, or exchanged for stable dung, it is important that as much as possible of it should be cut with the corn. This has introduced the practice called fagging, and sometimes bagging, the origin of which provincial expression is not well known. The instrument used for this purpose partakes of the nature of a scythe, as well as of a reaping-hook. It is shaped like a sickle, but is much larger and broader; and instead of being indented like a saw, it has a sharp edge like a scythe, which is renewed when blunt by means of a stone or bat. The fagging-hook cuts the straw close to the ground by a stroke of the hand; and its curved form is only useful in collecting stray stems, and holding a certain quantity of them between it and the left hand of the reaper when he makes up a sheaf. A certain quantity is cut towards the standing corn, the left hand pressing it down at the same time. When as much is thus cut as would make half a small sheaf, the reaper comes backwards, cutting in a direction at right angles to the first, and rolling together the two parts, which he carries in the bend of his hook and places on the band which has been prepared for him. A full-sized sheaf is usually composed of two cuttings. Two men will fully employ a third to make bands for them, tie up the sheaves, and set them up. This method of reaping is laborious, on account of the stooping required to cut near the ground. The *Hainault* scythe, which has been described in most agricultural works, does the work better, and with less fatigue. It is in fact a fagging-hook, not quite so curved, of which the handle is longer, and placed at an angle with the plane of the blade. It requires some practice to give the proper swing to it by a peculiar motion of the wrist; but when this is once acquired, a considerable saving of labour and time is effected. Many attempts have been made to bring it into use in England; but, from the obstinacy of the labourers, or the want of perseverance in the masters, without much success. A better instrument, however, on extensive farms, is the cradle-scythe, which, in the hands of an expert mower, will do more work and more effectually secure all the straw than any other instrument.

The objection to the great barn-room required for so much straw is obviated by the practice of stacking the corn in the open air, on proper stands to keep it dry and out of the reach of vermin. The additional trouble in threshing is not so great as that of mowing or raking the stubble, which is generally deferred till half of it is lost by decomposition by the air and moisture. When the saving of time is considered as well as the saving of expense, there seems to be no doubt that on an extensive farm the scythe is far preferable to the sickle for cutting every kind of grain. Barley and oats are usually mown and carried without tying them into sheaves, but this is a slovenly and wasteful practice: by means of the cradle-scythe they may be mown so regularly as to be readily tied into sheaves; and the additional expense will be fully compensated by the saving of all the corn which, being on the outside of the stack, is lost by the depredations of small birds.

Beans are usually reaped by the sickle, the stems being too strong and too wide apart to admit of the scythe. Where it can be done conveniently, without the soil adhering too much to the roots, it is better to pull them up, and tie them in bundles with straw bands, or tar-twine, which will be found both a convenient and economical method.

Peas are generally reaped by means of two large hooks similar to the fagging-hooks, one of which is held in each hand; and the stems, which are generally much interwoven, are partly cut and partly torn from the roots, and so rolled up into a small bundle laid loose in order that it may dry. Tares are reaped in the same way.

The expense of reaping corn is considerable, especially where the population is scanty. In the eastern counties men are engaged for the whole harvest, which, in favourable weather, is supposed to be completed in a month. During this time they have their usual daily wages, with or without food, and a certain sum besides, as harvest money. In other districts the labourers reap the corn by the acre, with a certain allowance of beer, or money instead of it. The price of fagging in Middlesex and within 30 miles around London varies from nine to twelve shillings per acre, according to the crop, and if it is lodged, as much as fifteen shillings is often paid, including beer. The use of the scythe considerably diminishes the expense, as fewer labourers are required.

There have been many attempts to introduce machinery for reaping corn; and within the past ten years the principle of the reaping-machine, invented by the Rev. Mr. Bell, of Forfarshire, a quarter of a century ago, and since successfully carried out in the United States of America, has been largely applied by many makers on both sides of the Atlantic, and we have now ten or twelve different reaping-machines, more or less differing from Bell's reaper, in successful operation. Many thousands of such machines are now at work in this country, and effect a great saving both of time and money at harvest time. Crosskill, of Beverley, manufactures Bell's reaper; Burgess & Key, of Newgate-street, manufacture M'Cormick's reaper, in which a serrated edge, oscillating in front of the corn, cuts it and lays it on a traversing screw/platform, by which, as in Bell's, it is carried aside and laid in swathes on the ground. Cuthbert, of Bedal, and many others, manufacture a smaller machine, in which the corn is delivered from the platform on which it falls by a man who rides on the machine. All these machines are in extensive and successful use.

REASON, according to the common notion, is the highest faculty of the human mind, by which man is distinguished from brutes, and which enables him to contemplate things spiritual as well as material, to weigh all that can be said or thought for and against them, and hence to draw conclusions, and to act accordingly. A man may therefore be said to possess reason in proportion as he actually exercises that power, that is, reasons and acts according to the conclusions or results at which he has arrived. In such expressions as "We have reason to believe such an account," or "He has no reason to be dissatisfied," the word "reason" does not signify the mental power itself, but the conclusion or result of the process of reasoning, in contradistinction to motives, which are never the results of mental operations, but merely outward circumstances by which our actions are influenced.

Thus far reason is of a purely practical nature, and Kant therefore divided reason (if we may venture to translate his word *Vernunft* by the English word *reason*) into practical and theoretical. The latter, which is also called pure, ideal, or transcendental reason, is, according to him, the mind's power of producing ideas *à priori* from its own resources, or the power of conceiving things and their attributes which lie beyond the sphere of our experience, such as infinity, the absolute, God, the supreme good, &c. How far our knowledge of these things can extend is shown in the work of Kant, entitled 'Kritik der reinen Vernunft,' or 'Criticism of Pure Reason.' Reason, in its practical acceptation, forms ideas *à posteriori*, in as far as it derives them from a consideration and comparison of the phenomena of the external world, endeavours to discover unity in variety, and traces all phenomena to one source, a supreme reason, of which human reason is only a reflex.

Schelling defines reason to be the identity of the subjective and the objective, that is, the identity of the power which knows and that which it knows, which includes the knowledge of this identity. As the original identity, says he, exists in God, or is God, reason is a direct knowledge or an intellectual perception of God, of whom no indirect knowledge is possible. Hence God and reason are essentially of the same nature; they are identical: God is in reason, and reason is in God.

(G. M. Klein, *Beiträge zum Studien der Philosophie als Wissenschaft des All.* There are some good remarks on this subject in S. T. Coleridge's *Aids to Reflection.*)

REBATE. [Discount.] -

REBEC (*Rebec*, Fr.), a musical instrument of the violin kind, which had three strings tuned in fifths, played on by a bow. This, which has long been in disuse, was small in size, something between the modern violin and the dancing-master's *kit*, or pocket-fiddle, and seems to have been the primitive violin. Laborde says that it was the favourite instrument of the minstrels; and the *ribible*, of which Chaucer and Gower speak, is supposed to have been the rebec. It was much used at festive entertainments. Milton, in *L'Allegro*, mentions it as the "jocund rebec."

REBELLION. [Sovereignty.]

REBUTTER. [Pleading.]

RECAPTION. [Replevin.]

RECAPTURE. [Prize.]

RECEIPT, a written discharge of a debtor on the payment of money due. When given for sums greater than two pounds, it must be stamped. Though evidence of payment, it is not absolute proof, and may accordingly be rebutted by showing that it has been given under mistake, or obtained by fraud.

RECEIVER. A receiver is a person appointed by the Court of Chancery to receive the rents and profits of land, or the produce of other property, which is in dispute in a cause in that court. He is an officer or agent of the court, and as such under its general control.

A receiver is never appointed unless a suit is pending concerning the property in question; and he is usually appointed upon motion in court, after notice has been given to the proper parties. The motion is generally made after answer; under special circumstances it may be made before answer, but the motion must be supported by sufficient affidavits. The cases in which a receiver is appointed are those in which there is great danger of property being wasted or lost, owing to the want of a proper person to look after it. The following are some instances in which a receiver will be appointed: when an infant is entitled to real estate, especially if it be of considerable magnitude: in suits between partners in trade for the purpose of winding up the concern, when a partner is grossly misconducting himself, disposing of the partnership property, or excluding his copartners from the management of the partnership affairs: when there is danger of the assets of a testator being lost or wasted through the misconduct of an executor. A manager of West India estates has power to set and let them, and to expend money in repairs; but a receiver has not such power, except as hereafter mentioned.

Certain persons are disqualified from being receivers, such as a solicitor in the cause, the next friend of the infant plaintiff, a peer of the realm, and a receiver-general of a county. The receiver must give security, according to the value of the property of which he is appointed receiver.

It is the duty of the receiver, when his appointment is completed, to inform the tenants of the estate in question of his appointment, that they may pay the rents to him.

A receiver is paid by a per centage on the sum which he receives, usually a shilling in the pound; and sometimes, in the case of large estates, by a fixed salary. He must annually pass his accounts of receipts and payments. It is usually directed in the order or decree for the appointment of a receiver, that the receiver shall from time to time pay the balances which shall be due from him into the Bank, with the privity of the Accountant-General, to the credit of the cause. A receiver who does not pass his accounts and pay in the balances may be deprived of his salary. (15 Ve. 273.) If he make default in payment of his balances, the recognizances may be put in suit. A receiver of rents and profits has to pass yearly or half-yearly accounts, as the rents and profits are received, and he is chargeable with interest at 5 per cent. on balances in his hands which he neglects to pay at the times fixed for that purpose.

When the receiver has passed his final account, and paid the balance into the Bank, or to the person entitled to receive the money, to whom the order directs him to pay it, he may apply by petition to the court for the vacating of the recognizances and his own discharge, and an order will be made accordingly, upon all the facts being proved to the court, which are the foundation of the receiver's right to his discharge. A receiver is not liable to make good unavoidable losses.

RECEIVER. [Distillation; Retort.]

RECIPROCAL, a mathematical term mostly applied to the fraction made by inverting another fraction; thus $\frac{3}{7}$ is the reciprocal of $\frac{7}{3}$, and $\frac{1}{7}$ of 7 or $\frac{7}{1}$. The term arises from the common meaning of the adjective reciprocal, and would be properly applied in every case in which A has to B the same sort of relation that B has to A. Custom however confines the absolute use of the term to that above-mentioned. A reciprocal property is one which each of two things has with reference to the other; thus if A and B be what are called conjugate diameters of a conic section, the tangent at either extremity of A is parallel to B, and that at either extremity of B is parallel to A. Hence these lines are reciprocally connected with each other, and are therefore called conjugate; for the word conjugate, which denotes joined, generally means joined by a reciprocal property.

RECITATIVE (*Recitativo*, It.), language delivered in musical tones, that is, in the sounds of the musical scale. It differs from the air in having no fixed time or measure, the lengths of the notes depending on the singer, who regulates them according to his own notion of the emphasis and expression required; and it is not governed by any principal or predominant key, though its final cadence or close must be in some cognate key of the air which follows, or, at least, in no very remote key. Recitative is of two kinds—*Unaccompanied* and *Accompanied.* The first is when a few occasional chords are struck by the piano-forte, or by a violoncello, to give the singer the pitch, and intimate to him the harmony. The second is when all, or a considerable portion, of the instruments in the orchestra accompany the singer, either in sustained chords or in florid passages, as the composer may deem expedient, in order to give the true expression or colouring to the passion or sentiment to be expressed. Perhaps the Italian definition of recitative, *musica parlante*—speaking music—is the best, as it certainly is the most concise, that can be offered.

There can be no doubt that the language of the ancient drama, both Greek and Roman, was delivered in a kind of recitative. [Music; Opera.]

RECKONING AT SEA is the process of computing the several elements which relate to the determination of the ship's place at any time. The term may include the operations which are performed in finding the latitude and longitude of the ship, the variation of the the needle, &c., from celestial observations; and the part which is independent of these is called the *dead-reckoning*. It is this last only which we purpose here to explain.

When a ship crosses the seas towards the place of its destination, its path, on account of the various winds, currents, &c., by which it is impelled, is always indirect, and generally consists of numerous zig-zags, whose portions are lines of a few miles in length. The length of each of these lines, and the angle which it makes with the terrestrial meridian passing through one of its extremities (all necessary corrections having been made) are the data obtained by the *log-line* and *compass;* and the earth being supposed to be a sphere, those lines might be considered as arcs of great circles. Hence the rules of spherical trigonometry might be employed to find the length of an arc joining the two extremities of the series of indirect lines, and the angle which it makes with the meridian passing through either of those extremities; and, from these, the geographical position of the ship. But, because this process is considered laborious, others possessing greater facilities are, according to circumstances, employed, and these will be described after it has been shown what are the corrections which the observed elements require before they can be used in the computations.

The reckoning may be said to commence when the ship is on the point of quitting a harbour or road; and the first circumstances to be recorded are the observed bearing and the estimated distance of some remarkable object on the coast whose geographical position is known, together with the bearing of the ship's line of motion at the time, and her velocity on that line.

Let it be here observed that the said object on the coast is called the point of *departure*, and that the angle which the line of a ship's motion at any time makes with the meridian passing through the actual position of the ship is called her *course*. Now, while the angle indicated by the compass remains the same, the ship's path, except when it coincides with the meridian, or with a line tending due east and west, is a portion of that which is called the *loxodromic curve* [RHUMB-LINE]; yet, to the extent of a few miles, it is the custom to consider it as a right line, and, therefore, as making a constant angle with the meridian passing through one of its extremities. The deviation of the magnetic from the true meridian (the declination or variation of the needle) differing in different places, the amount of that variation (ascertained by celestial observations as often as possible) must be added to or subtracted from the angles observed with the compass, in order to have the bearing, or course, from the true meridian. But while a ship is sailing with the wind in a direction oblique to the line of her keel, she is compelled, by the force of the wind and the resistance of the water against her side, to move in the direction of a line which makes some angle with her keel on the side opposite to that from which the wind is blowing; this angle is called the *lee-way*, and as it differs for different ships, it must always be determined by trial in some one of the ways proposed in treatises on navigation. The estimated amount of the lee-way is a second correction, which must be applied to the course observed with the compass, in order to obtain the correct angle with the meridian.

The velocity of the ship is ascertained by means of the log-line [LOG-LINE], which at once indicates the number of geographical miles (equatorial minutes) she has passed over in an hour; and consequently, supposing her motion to be uniform, the space through which the ship has sailed on a particular course in a given number of hours is known. This is technically called the *distance*.

Again, when a ship is sailing either in a current of the ocean, or in a tide near a shore, her velocity and the direction of her motion will be affected by those of the current or tide. First, if the ship is impelled by the wind in the same direction as the current is moving, it is evident that the velocity given by the log will be only the difference between the ship's real velocity and that of the current, and consequently the latter must be added to the velocity given by the log in order to have the true velocity. On the other hand, if the ship is impelled by the wind in a direction contrary to that of the current, the velocity of the latter must be subtracted from that given by the log, in order to obtain the true velocity of the ship. Again, if the direction of the current is oblique to the line of the ship's motion according to the compass, the true path and velocity of the ship will, by the *composition of motions*, be the diagonal of a parallelogram formed on lines representing the observed directions and velocities of the ship and current; consequently, since this rule is the same as that by which is found a path of the ship which shall be equivalent in length and direction to any two successive paths whose lengths and directions are given, it is evident that among the registered courses and velocities of a ship it will be only necessary to insert the observed direction and velocity of the current, as if the ship had actually moved in that direction, and with that velocity during the time that she continued to sail in the current. The like remark may be made respecting the deviation of a ship from the course on which she appears by the compass to have sailed, in consequence of a swell of the sea, by which she may be driven in some other direction. This direction must be observed, and the velocity estimated according to the judgment of the seaman.

Now, in order to show how all the corrections may be applied to the observed elements, let it be supposed that at the noon of some day a remarkable object A on the shore was observed by the compass to bear W. by N., and that its estimated distance from the ship was 20 miles. At the same moment let the ship begin to sail on a course which is S.W. by the compass; and let the velocity by the log be 3 knots, or 3 miles per hour. Also let the following table express the several memoranda in the order in which they may be supposed to have been made in the course of one day; that is, according to the practice of seamen, between the noon of one day and the noon of the next.

The bearing of the ship from the point of departure being corrected for the variation of the needle becomes N. 78° 15′ E.; the distance is 20 miles.

Day of Month.	Hour.	Knots.	Wind.	Course.	Lee-way.	Remarks.
	Noon.	3	W.N.W.	S.W. (or S. 45° W.)	0.	The point A of departure bore W. by N., distant 20 miles; its lat. ——, and long. ——.
	2 P.M.	4½				
	8	5¼				
	10	6	W. by N.	S.E. by S. (or S. 33° 45′ E.)	¼ E., or 2° 49′ E.	A swell setting towards E.N.E. from 2 P.M. to 8 P.M.: velocity 6 miles per hour.
	12	4½				
	6 A.M.	5¾				
	8	6	W.	S.S.W. (or S. 22° 30′ W.)	1 E., or 11° 15′ E.	A current setting towards S.S.E. from 10 A.M. to 10 P.M.: velocity 2 miles per hour. Variation N. 24° W.
	10	6½				

The first course corrected in like manner becomes S. 21° W.; and the distance run between noon and 10 P.M. is 43·5 miles.

The third course corrected for lee-way and variation becomes S. 60° 34′ E.; and the distance run between 10 P.M. and 8 A.M. is 50·5 miles.

The fourth course corrected in like manner becomes S. 12° 45′ E.; and the distance run between 8 A.M. and noon is 25 miles.

The direction of the swell corrected for the variation of the needle becomes N. 43° 30′ E.; and the distance is 36 miles. Lastly, the direction of the current corrected also for the variation becomes S. 46° 30′ E.; and the distance is 24 miles.

These corrected courses and distances are then inserted in order, as in the first and second columns of the following table:—

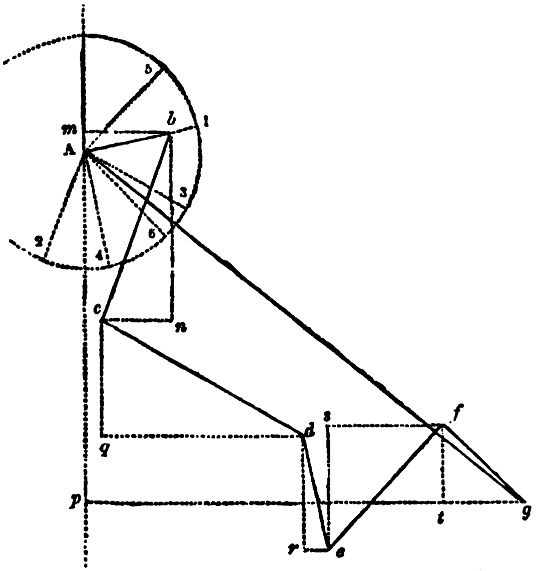
Courses.	Distances.	N.	S.	E.	W.
N. 78° 15′ E.	20	4·07 (=A*m*)	. . .	19·58 (=*bm*)	. . .
S. 21° W.	43·5	. . .	40·7 (=*bn*)	. . .	15·50 (=*cn*)
S. 60° 34′ E.	50·5	. . .	24·82 (=*cq*)	43·98 (=*dq*)	. . .
S. 12° 45′ E.	25	. . .	24·38 (=*dr*)	5·52 (=*re*)	. . .
N. 43° 30′ E.	36	26·11 (=*se*)	. . .	24·78 (=*sf*)	. . .
S. 46° 30′ E.	24	. . .	16·52 (=*ft*)	17·41 (=*gt*)	. . .

Now, if the navigation is comprehended within about ten degrees on each side of the equator, such a zone of the earth may be supposed to be projected on the interior surface of a circumscribing cylinder, and then developed on a plane; in which state the meridians and the parallels of latitude become right lines parallel to themselves' respectively, and the length of a degree of longitude on every parallel equal to that of a degree on the equator or on the meridians. This is called the *plane chart*, and the projection of a ship's path on it is called *plane sailing*.

Let the several directions in which the ship has moved, and the distances passed over in each direction, be represented in the subjoined diagram, the construction of which, agreeably to the nature of the plane chart, is as follows:—

Draw the lines A 1, A 2, A 3, &c., making with A*p*, the meridian of the point of departure, angles equal to the several courses as they occur successively in the preceding table (col. 1), and draw the lines *bc*, *cd*, &c., parallel to A 2, A 3, &c., respectively; the distances A*b*, *bc*, *cd*, &c., being laid down according to the successive numbers in col. 2 by a scale of equal parts representing geographical miles (or equatorial minutes). At the end of the day the ship is arrived at the point *g*;

therefore if A and *g* be joined, and *gp* be drawn perpendicularly to A*p*, the angle *p*A*g* is the resulting course, A*g* the resulting distance, A*p* the



difference of latitude between A and *g*, and *pg* is what is called the *departure*, which, in plane sailing, is identical with the difference of longitude between the same points A and *g*.

By drawing lines perpendicular and parallel to A*p*, as in the above diagram, there will be formed the several right-angled plane triangles A*bm*, *bcn*, &c., in each of which there are given the hypothenuse and the angles; and consequently by the rules of plane trigonometry the several sides A*m*, *bm*, *cn*, *bn*, &c., may be computed. Now, let these computed values be placed in the third and succeeding columns of the above table in the following order:—those which are parallel to A*p* in the column N. or S., according as the lines which represent them lie towards the north or towards the south of that extremity which is first, in order of sailing, on the corresponding hypothenuse; and those which are perpendicular to A*p* in the column E. or W., according as the lines which represent them lie towards the east or west of that same extremity. Then the sum of the numbers in the column N. being subtracted from the sum of those in S. will be found to leave 76·24, and this will be the value of A*p* in geographical miles (or equatorial minutes); consequently 1° 16′ 14″ will express the extent in latitude to which, on the whole, the ship has sailed southwards during the day. Again the number in W. being subtracted from the sum of those in E. will leave 95·68 (=1° 35′ 41″), and this will be the value of *pg*, or the extent in longitude which, on the whole, the ship has sailed eastward during the day. Thus the position of A being known, we have that of *g*. In the right-angled plane triangle A*pg*, having A*p* and *pg* in miles, as above, we may compute A*g* and the angle *p*A*g*, that is, the resulting distance and course. The former will be found to be =122·35 miles, and the latter S. 51° 27′ E. The series of zig-zag lines which a ship may describe is called a *traverse*; the preceding table is called a *traverse table*, and the whole operation of finding the resulting course and distance is called *traverse sailing*.

In practice, both the construction and calculation above indicated are superseded by the use of the table of *difference of latitude* and *departure*, which is given in treatises on navigation, and is called a traverse table. The numbers in the table are nothing more than the computed values of the sides of right-angled triangles; the hypothenuse, or the distance, and the adjacent angle, or the course, being given. Thus, by referring to such a table, the courses and distances being used as arguments, the numbers in the columns N. S. E. W. above, might have been found sufficiently near the truth. And, conversely, seeking in the table the difference of latitude (=76) and the departure (=96), the corresponding distance (=122) would be seen in its proper column, and the angle or course (=51°) at the bottom of the page.

The logarithmic or Gunter's scale [SCALE] was formerly, for the sake of expedition, much used in the resolution both of plain and spherical triangles for the purposes of navigation. If, for example, it were required by that instrument to find the values of *cq* and *qd* in the triangle *cqd*, the following proportions

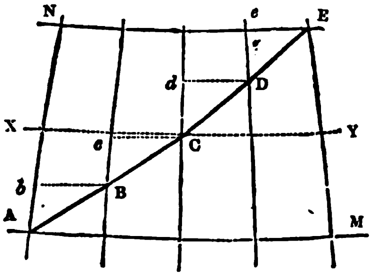
Rad. : sin. *qcd* (60° 34′) : : *cd* (50·5) *qd* (=44)
Rad. : sin. *cdq* (29° 26′) : : *cd* : *cq* (=25)

might be worked by taking in the compasses the distance from 90° to 60° 34′ on the line of sines, and applying that distance on the line of numbers from 50·5 towards zero; the other foot of the compasses would fall on 44, which is the value of *qd*; again by taking the distance from 90° to 29° 26′ on the line of sines, and applying it on the line of numbers, from 50·5, as before, the other foot of the compasses would fall on 25, which is the value of *cq*. But it is evident that when the angle is small, or nearly a right angle, the instrument must be very inaccurate.

Should a ship, on any part of the earth's surface, sail for a short time in a direction either due east or due west, so that during that time it might be considered, without sensible error, as sailing on the circumference of a parallel of latitude, the determination of its place is obtained by a different process. Thus, the earth being supposed to be a sphere, the length, in miles, of any arc of the equator between the meridian circles passing through its extremities is to the length, in miles, of the arc between the same meridians on any given parallel of latitude as radius is to the cosine of the latitude of the parallel. Therefore, when the number of geographical miles passed over on any parallel of latitude is known by the log (all due corrections being supposed to be made), the difference of longitude corresponding to that distance may be found at once by the above proportion. Evidently also, if any three whatever of the terms are given, the fourth can be found; and thus every variation of the case may be resolved. This is called *parallel sailing*.

But the tables of difference of latitude and departure may be rendered available for finding the required term if we consider the latitude of the parallel on which the ship is sailing to represent what is called the *course* in those tables; the distance in miles on the parallel as the *difference of latitude*, and the difference of longitude in geographical miles as the *distance* in the tables; and then, by inspection as before, the required term may be found.

The third method of operating, which is called *middle latitude sailing*, has been defined under LONGITUDE AND LATITUDE, METHODS OF FINDING, and we have here only to point out its application. Let A E be a portion of the rhumb-line which a ship describes while her motion continues to coincide with the direction of one point of the compass, that is to say, while it makes a constant angle with the meridians of her successive places. Let this curve be divided into any parts, A B, B C, &c., of small extent, so that each part may, without sensible error, be considered as a straight line; and imagine both meridians and parallels of latitude to be drawn through A, B, C, &c. Then the several triangles B A *b*, C B *c*, &c., being considered as plane triangles, if the constant angle B A *b*, C B *c*, &c., be represented by A, we shall have—



A B cos. A=A *b*, B C cos. A=B *c*, &c.; also
A B sin. A=B *b*, B C sin. A=C *c*, &c.; whence, by addition,—
(A B+B C+&c.) cos. A=A *b*+B *c*+&c., and
(A B+B C+&c.) sin. A=B *b*+C *c*+&c.

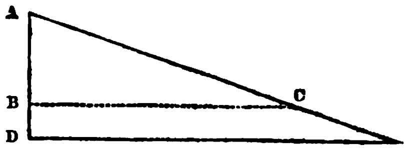
It is evident therefore that the sum of all the distances multiplied by the cosine of the course will be equal to E M, the difference between the latitudes of A and E as in plane sailing; but the sum of all the distances multiplied by the sine of the course (that is, the sum of all the departures, B *b*, C *c*, &c.) will be less than A M and greater than N E. Therefore, as an approximation to the truth, we may consider the sum of all these departures as the length, in miles, of the arc X Y (between A N and M E) of a parallel of latitude equally distant from A M and N E; that is, of a parallel whose latitude is an arithmetical mean between the latitudes of A and E. Consequently, as in the theorem for parallel sailing, the difference between the longitudes of A and E will be obtained from the proportion

Cos. *mid. lat.* (=lat. of X Y) : Rad. : : (A B+B C+&c.) sin. A : diff. of long.;

and, instead of working the proportion, the tables of difference of latitude and departure may be used as before.

If we imagine the earth's surface to be developed on a plane so that the meridians and parallels of latitude may be respectively parallel to themselves as in the plane chart; and if the lengths of infinitely small portions of the circumference of the equator have to the lengths of corresponding portions of a meridian, in any latitude, the ratio that the radius bears to the secant of that latitude [MERCATOR'S PROJECTION; RHUMB-LINE], there may be formed a species of chart which will afford a general and at the same time a sufficiently easy method of determining the elements relating to a ship's place. This method is called *Mercator's sailing*. In the chart just alluded to, the length of a degree, minute, &c., of longitude, on any parallel of latitude, is constant, being the same as the length on the equator, on account of the parallelism of the meridians; but, in any latitude, the length of a small meridional arc (which, without sensible error, may be of one minute) varying with the secant of the latitude of the arc, the distance, on the map, of any parallel of latitude from the equator will be equal to the sum of the secants of all the minutes in the degrees, &c., expressing the latitude of the parallel. Now, in the tables of *meridional parts* which are given in treatises on navigation, the numbers under the arguments 1 min., 2 min., 3 min., &c., express the values of such sums of secants, the length of an equatorial minute (or geographical mile) being unity. Hence the difference between the numbers, in the table, corresponding to the latitudes of two given points, will express the number of such minutes or miles on the map between these points.

By the help of this table a triangle may be always constructed with the data of the problem; and the terms required may be obtained by measurement. In the subjoined figure, let AD be the direction of the meridian passing through the ship at A, and BAC be her course; then, if AC be made equal to the distance in miles by a scale of equal parts, and BC be drawn perpendicular to AD, AB and BC measured on the same scale will be the difference of latitude and departure as in plane sailing. Now, if AD be made, by the same scale, equal to the difference between the meridional parts which, in the table, correspond to the latitudes of the point A and C, and DE be drawn parallel to BC, DE on the same scale will express, in miles or minutes, the true difference between the longitudes of A and C.



What has been said may serve as an example of the manner of constructing the triangle, when the course, the distance, and the latitudes of the two extremities of the distance-line are given, and it is required to find the difference between the longitudes of those extremities. Again, let the ship's course and distance from any point A, and also the latitude of that point, be given, to find the differences both of longitude and latitude. The formation of the triangle ABC is the same as that just mentioned, and AB being measured on the scale of equal parts is the true difference of latitude (in miles or minutes); this being added to or subtracted from the latitude of A, gives the latitude of C. Then, with these latitudes, find from the table the difference between the meridional parts, and proceed as before to find the difference of longitude. If the latitudes of the ship at two places were given, and also the distance between those places, and it were required to find the course and the difference of longitude:—on the meridian line passing through one of the places A, make AB equal to the difference of latitude in miles by the scale of equal parts, and make AD by the same scale equal to the difference between the meridional parts, in the table, corresponding to the latitudes; then draw the indefinite perpendiculars BC and DE, and from A as a centre with a radius equal to the given distance describe an arc intersecting BC in C. Join A and C, and produce the line to E; then ∠BAC will be the course, and DE, measured as before, the difference of longitude.

It is easy to perceive that the table of differences of latitude and departures may be used in Mercator's sailing in the same way as it would be employed in plane sailing, if the meridional difference of the latitudes, from the table of meridional parts, be made to hold the place of the simple difference of latitude. Thus, in the second of the above examples, with the given course and distance, find by inspection in the first-mentioned table the difference of latitude; then, having got by addition or subtraction the latitude of the place at which the ship is arrived, find in the table of meridional parts the numbers corresponding to those latitudes, and take their difference. Lastly, with this difference, as a simple difference of latitude, and with the course, find the departure by inspection in the first table; this departure is the required difference of longitude.

When a ship is in a high latitude, it is necessary to determine the difference of longitude, either by middle latitude or by Mercator's sailing, for every particular course on which the ship may have sailed.

The daily differences of latitude and longitude being thus obtained, the seaman knows, within the degree of accuracy of which his data admit, the latitude and longitude of the ship on any day; but it is easy to perceive that the uncertainties respecting the estimates of the distances run, the variations of the needle, the effects produced by currents, &c., must, in time, render the results of the reckoning very erroneous; and therefore it is of the utmost importance to correct them frequently by celestial observations. The determination of the latitude by meridional or other altitudes is easy; and that of the longitude by lunar distances or by chronometers should be made as often as possible. Every geographical position thus determined with precision serves, by comparison with the results of the dead-reckoning, to lead to a knowledge of the causes of the errors which exist in the latter, and becomes a point of departure for the next succeeding portion of the voyage.

RECOGNISANCE is an obligation of record, entered into before some court of record, or magistrate duly authorised, by which the party entering into it (the cognisor), whose signature is not necessary, acknowledges (recognises) that he owes a sum of money to the queen, or to some private individual, who is called the cognisee. This sum is named the amount of the recognisance. The acknowledgment is generally followed by an undertaking on the part of the cognisor to do some act, such as to keep the peace, to pay a sum of money, to attend to give evidence, &c. On the performance of this act, the cognisor is discharged from his recognisance. On his default, the recognisance is forfeited, and he becomes indebted absolutely to the amount of the recognisance. A debt on recognisance takes precedence of other debts, and binds the lands of the cognisor from the time of its enrolment. If the recognisance is made to a private individual in the nature of a statute staple, &c., he may on its forfeiture, by virtue of process directed to the sheriff, obtain delivery of the lands and goods of the cognisor till the debt is satisfied, or proceed against the cognisor in an action of debt, or by scire facias. If the recognisance is made to the crown, it was formerly, in all cases of forfeiture, estreated into the exchequer, and afterwards recovered by process from that court to the use of the treasury. But now forfeited recognisances taken before the court of quarter-sessions, or justices of the peace, are enrolled among the sessions records, and recovered by the sheriff; a list of the amounts being yearly returned by the clerks of the peace and town-clerks for their districts respectively, to the lords of the treasury. Where a recognisance has been estreated into the exchequer, that court may discharge or compound it according to the justice of the case.

RECONNOISSANCE is an examination of a tract of country or of the sea-coast; the latter previously to a disembarkation of troops, and the former preparatory to the march of an army in order either to meet that of the enemy or to take up quarters for the season.

The *military reconnoissance* of a country is a duty appertaining primarily to the officers on the staff of the quartermaster-general, though in many cases, such as sieges, &c., it is necessarily carried out by the engineers; and if the enemy is in the neighbourhood, it is performed under the protection of an armed force. It is considered as one of the most essential operations connected with the tactics of the field, and serves as the basis of every movement or combination which it may be proposed to make.

A general knowledge of a country which is or may become the seat of war—that is to say, a knowledge of the positions of its fortified places, the directions of its mountains, rivers, and great roads—may be obtained from maps or from geographical descriptions; but that which is necessary for the immediate purposes of a campaign can only be acquired by an actual survey of the ground in detail, and by inquiries made on the spot respecting the means which the country may afford for supplying the wants of the army.

The Maréchal Puysegur (1690) appears to have been the first in modern warfare who regularly performed this duty by examining personally the tract through which the army was to march, or in which it was to encamp, and of deciding beforehand on the best routes and positions. He observes ('Art de la Guerre') that before his time it had been customáry to trust for a knowledge of these points to the reports of the country-people, or of officers who might accidentally have been on the ground. He adds that disasters frequently occurred by the lines of march being improperly chosen, and that sometimes, after fatiguing marches, and after all the labour of encamping had been undergone, the troops had been compelled to abandon the positions on account of their unfitness. Since that time, armies being more numerous and more widely disseminated, consequently requiring more vigilance in the communication of one part with another, and a greater extent of country for their support, the reconnoissances have been made on a greater scale, and in the military establishments of every nation officers are now particularly instructed in all the details of that branch of service.

Those who are charged with this duty should be habituated to the performance of topographical surveys: in the first place by the most accurate methods and with the best instruments; and secondly, by such methods as admit of being practised rapidly on foot or on horseback. In these cases, an azimuth compass held in the hand must be used for observing the angles, and the distances must be obtained by pacing, or be merely estimated by the eye. A micrometer scale, divided to 200ths of an inch, fixed in the eye-piece of a telescope, will give distances with comparatively great accuracy and great ease, as it is only necessary to see how many divisions an object subtends, and on arriving at it to measure it, the focal length of telescope having been previously determined by experiment. A facility in representing on the plan the inequalities of the ground is also highly necessary.

In making the reconnoissances previously to the march of an army, the whole of the ground between the actual position of the latter and that which is intended to be occupied should be surveyed if the enemy is near and there is danger of his attacking the columns by surprise; otherwise it may be sufficient to survey the ground within a few hundred paces on each side of the roads by which the columns are to march. A complete plan of the tract of country in which the reconnoissance is made may therefore be required; or it may suffice to represent on paper the line or lines of march. In either case the officer may be provided with a general map, or an itinerary of the intended route, as an outline for his guidance; and his survey, when completed, should be accompanied by a report or memoir, stating in detail what cannot be conveniently represented on the plan. In this report should be expressed, with all necessary references to the plan of the ground, the distances, by the different routes, between the two positions, and the places where troops may halt for repose or to form in order of battle, distinguishing particularly the plains where cavalry may act, and the heights on which artillery may be placed. The nature of the roads should be described, with indications denoting that they are passable for artillery, for cavalry, or merely for infantry; and if defective, estimates should be made of the materials and time requisite for repairing them. It is particularly necessary to state whether the ascents and descents are gentle or abrupt; and, when the road is on the side of a hill, whether it is sufficiently level to allow artillery or carriages to pass safely. It should also be noticed whether or not, at places where roads run through towns, they are reduced to narrow and winding streets. The breadths and velocities of rivers, streams, and canals which cross the lines of march should be ascertained, and a statement made whether the beds are rocky, gravelly, or muddy; also whether the banks are high or low. Mention should also be made of the means which exist for passing them; of the places where they are fordable, where there are ferries or bridges, or where boats may be procured: descriptions should also be given of the bridges or boats, and the manner of working the latter. The situations and extent of marshes should also be shown, and it should be stated whether they are passable or can be made so. In contemplating rivers and marshes as means of retarding an advance of the enemy, it should be ascertained and reported whether, by being dry in summer or frozen in winter, they may not at times cease to be obstacles. It should also be stated how, on a retreat, the roads may be blocked up, the fords rendered impassable, or the bridges destroyed.

Should a sufficient number of roads for the different columns not exist, the officer is to ascertain whether or not others may be made by cutting through hedges, walls, or woods, by forming causeways over marshes, or by constructing or repairing bridges over rivers or streams; and also whether the country affords the materials necessary for these purposes. The rates at which it is possible for troops to march in the several roads, defiles, &c., must be estimated according to the breadth of the latter or the degree of their practicability; for on a right estimate of such rate, together with the known length of the road, depend the number of battalions and the class of troops which ought to be appointed to follow each particular route, when it is required that the different columns should arrive at the same time in some given position. The plan should show the situations of farms, mills, houses, &c., which may be capable of being defended or of affording quarters for the troops; and on it should be indicated, by some scale of numbers or otherwise, the relative heights of the ground, that it may be ascertained what positions can be occupied with advantage for offensive or defensive operations. The representation of a simple line of march should also indicate the places where roads diverge from or cross the route, with the distances of the nearest towns or villages from thence; and any particular survey of the ground for an encampment should extend to at least a mile every way beyond the supposed chain of outposts. [MILITARY POSITIONS; PIQUET.] The report must state what are the resources of the country in corn, cattle, and forage; and the number of carriages, horses, and other draught animals that it may furnish for the conveyance of artillery and stores. If the line of march is in the direction of a navigable river which may be available for the last-mentioned purpose, it will be necessary to ascertain its breadth and rapidity, and also the obstructions which may be met with from shallows, weirs, &c. Marshal Suchet caused his artillery to be conveyed by the Ebro from Mequinenza to Xerta, in 1810, preparatory to forming the siege of Tortosa.

An open country presents the greatest facilities for reconnoitring, since the positions of its towns or villages, and the directions of its roads and rivers, can then be easily distinguished and represented on paper. A tract covered with wood is not only surveyed with difficulty, but it imposes on the officer, in addition, the necessity of ascertaining all the directions in which it is capable of being penetrated by the enemy, and in what manner the passes may be blocked up or defended. Open plains intermingled with wood, fields surrounded by hedges, ground intersected by streams of water, ravines, and hollow ways, demand great exactness in the survey, since such tracts afford the most important advantages, both in the higher and in the secondary operations of warfare, to the army which is best acquainted with their details. They allow troops to pass unseen from one point to another when a surprise is attempted or a rapid retreat is to be made; they also afford cover from whence the enemy may be annoyed with little loss. In mountainous districts it is important to ascertain the forms and directions of the chains of heights, with their acclivities on both sides; and, if the line of march is between them, the collateral ravines should be examined to a considerable distance: the commencements and directions of the ravines should also be shown, and all the defiles by which the valleys communicate with each other. Through these defiles troops detached from the army are enabled to fall suddenly on the enemy during his march, to separate his columns, and intercept his supplies or cut off his retreat; and, on the other hand, since the enemy may attempt the like measures, it becomes necessary that the officer employed to reconnoitre should ascertain by what means the passes may be barricaded, either to impede the enemy or enable the troops to defend themselves.

In reconnoitring a country, when it is intended to act on the defensive, it should be well known by what roads the enemy can penetrate, and where are the best situations for forming intrenched camps or establishing posts in order to be enabled to keep the field and cover the magazines. Again, if it be intended to carry the war into an enemy's country, it is necessary to discover the position occupied by his army; to find the tract of country most proper for the march, and the spots where the localities permit encampments to be formed with due support on the flanks and security in the rear. If it be intended to besiege a fortress or to attack the enemy's position, the reconnoissance may be made quite up to the glacis of the place, or to the works which protect the position. In the former case it is necessary to ascertain the nature of the fortifications, and the fitness of the ground about them for the operations of the siege; and in the latter, to find out the strength and dispositions of the enemy's troops. An armed force is generally required on these occasions, as, in order to approach near enough for the purpose, it may be necessary to drive in some of the outposts. During the war which ended in 1814, the English and French out-sentries appear to have entertained a mutual understanding not to molest each other, and to retire to their supports before they commenced firing when either army was about to make a movement. Colonel Napier relates that Lord Wellington, being once desirous of reconnoitring the enemy's position at Bayonne, ordered his escort to fire upon some of the enemy who occupied the top of a hill which he wished to ascend; but one of the men going up to the French soldiers and tapping his musket in a particular way, the latter, who understood the signal, quietly withdrew.

In a *maritime reconnoissance* the circumstances which it is of most importance to ascertain are: whether the coast is rocky or bordered by downs, and what is the state of the bays or roads with respect to shelter from the prevailing winds; the seasons in which winds blow off and on the shore, and whether the anchorage is secure or otherwise; the nature of the tides, the hours of high and low water, and the depth at either of those times. Precise information should also be obtained of the places at which troops might land, and where there exist rising grounds on which artillery may be disposed to protect them. Rivers should be ascended to a considerable distance if possible, in order to ascertain their depths and the nature of the vessels employed on them by the people of the country. On the other hand, if it were required to examine the coast preparatory to putting it in a state of defence, it would be necessary to find out what points of land are convenient for the situations of forts or batteries by which the enemy may be prevented from landing, and where beacons may be established for the purpose of giving timely alarm. If there are islands on the coast, it would be proper to include them in the survey, since they might be fortified and made to serve as advanced works; and all places should be indicated which are capable of being converted into military posts to prevent the enemy from penetrating into the interior of the country.

RECORD, a memorial in rolls of parchment of the proceedings and acts of a court of law, upon whose proceedings error will lie. An act of a party which is put on record cannot be varied even in the same term, but a judicial act of the court may be altered during the same term. If a record is lost, the court may order a new entry to be made at any time. In order to prove a record the existence of which has not been denied on the pleadings, an examined copy is sufficient. But if the existence is denied on the pleadings, it can only be proved upon inspection by the court of the record itself; and that is conclusive not only as to the existence of the record, but as to all matters stated in it. For the record of a court of competent jurisdiction is legally considered as the indisputable proof of all those proceedings having taken place which the record sets forth; and no averment to the contrary in pleading can be made. A record found in the proper office is legally assumed to have been always in the same plight in which it is found. The effect of a reversal of a judgment in error is to annul the previous record from the commencement. ('Co. Litt.,' 117 b., 260 a.; Com. 'Dig.,' tit. 'Record.') As to what constitutes a Court of Record, see COURTS, and RECORDER.

RECORDER (*Recordator*), a judicial officer, described by Cowell as "he whom the mayor or other magistrate of any city or town corporate having jurisdiction, or a court of record, within their precincts by the king's grant, doth associate unto him for his better direction in matters of justice and proceedings according to law." The Norman term, *recordeur*, appears to have originally been applied to every person who was present at a judicial proceeding, and to whose remembrance, or record, of what had taken place the law gave credit in respect of his personal or official weight and dignity. Of this we perceive a trace in the ordinary writ of Accedas ad Curiam, by which the sheriff is commanded to go to some inferior court (which, not being the king's court, is not a court of record), taking with him four knights, and there to record the plaint, which is in that court; the remembrance of the four knightly recordeurs of what they saw existing in the inferior court, in obedience to the king's writ, being treated as equivalent to their actual presence at the proceeding to be recorded. So if the proceedings are in the sheriff's court, he is ordered by the writ of Recordari facias loquelam to cause the plaint to be recorded by four knights. And by a record of the 8th year of King John, we find that a judgment of battle in the court of the archbishop of Canterbury being vouched in the king's courts, four knights were sent to inspect the proceedings, who returned "quod recordati sunt.' ('Placitorum Abbreviatio,' 54.) The practice of certifying and *recording* the customs of London *by the mouth of the recorder*, which is antecedent to the charters granting or recognising the practice, appears to be referrible to the same source. Where criminal or civil jurisdiction was exercised by citizens or burgesses, it would add to the importance of the court if its proceedings took place in the presence of an officer to whose *record* the superior courts would give credit, either in respect of his personal rank, as a peer or knight, or on account of his connection with those courts, as a serjeant or barrister-at-law. [SERJEANT.]

Since 1835 the duties of recorders in the cities and boroughs coming within the operation of the Municipal Corporations Act (5 & 6 Will. IV., c. 70), have been regulated by the provisions of that and of subsequent statutes. The jurisdiction of the recorder in places of minor importance will not require to be noticed. Nor do these acts affect the city of London.

I. The recorder of London is a judge having criminal and civil jurisdiction. He is also the adviser and the advocate of the corporation. In respect of the duties performed by the recorder in the assemblies of the corporation, in the courts of mayor and aldermen, of common council, and of common hall, his office may be said to be ministerial. He is by charter a justice of the peace within the city of London, and a justice of oyer and terminer, and a justice of the peace, in the borough of Southwark.

The first charter of Edward IV. to the city of London grants that the customs of the city be certified and *recorded* by word of mouth, and that the mayor and aldermen of the city and their successors do declare by the recorder whether the thing under dispute be a custom or not.

The business of the mayor's court, in which the recorder ordinarily presides alone, comprehends a court of equity. In the mayor's court the recorder tries civil causes, both according to the ordinary course of common law and the peculiar customs of the city. The amount for which such actions may be brought is unlimited.

All the duties of a justice of the peace, including those of chairman, devolve upon the recorder at the quarter and other sessions held at Guildhall for the city of London. At the twelve sessions which are held yearly at the Old Bailey, the recorder acts as one of the judges under her majesty's commission of oyer and terminer, and general jail delivery.

The annual salary of the recorder of London is 3000*l.* Besides this, he has fees on all cases and briefs which come to him from the corporation, and he is also allowed to continue his private practice.

The recorder is elected by the court of aldermen, most commonly at a special court held for the purpose. Any alderman may put any freeman of the city in nomination as a candidate for the office, but an actual contest seldom takes place. The recorder elect is admitted and sworn in before the court of aldermen. The appointment is during good behaviour, that is, in contemplation of law, for life. The recorder has always been a serjeant-at-law or a barrister. The office has been held by men of considerable eminence: of eleven persons who filled the situation during the last century, one became lord chancellor; another, master of the rolls; another, chief justice of the Common Pleas; and two, barons of the Exchequer.

By an order made by the court of aldermen in the reign of Philip and Mary, the recorder, common-serjeant, and judge of the sheriff's court, were directed to be chosen "from old and learned officers of the city or out of the number of the six learned counsellors," that number comprehending, in addition to the ordinary city counsel, the attorney and solicitor-general, who were always retained for the city. Four persons by whom the recordership of London has been held during the present century, have previously filled the office of common-serjeant. [SERJEANT.] But no similar instance occurred during the 18th century.

The recorder of London deriving his authority from charters, and not being appointed by commission (except temporarily as included with other judges in the commission of oyer and terminer, &c., at the Old Bailey), he is not, like the judges of the superior courts, liable to dismissal by the crown upon an address by both Houses of Parliament. But all recorders may be removed for incapacity or misconduct by a proceeding at common law.

Deputy recorders have, in some instances, been appointed by the court of aldermen on the nomination of the recorder. ('Report on Municipal Corporations.')

II. In cities and boroughs within the Municipal Corporations Act, the recorder (who must be a barrister of not less than five years' standing) is a judicial officer appointed under the sign manual by the crown during good behaviour, having criminal and civil jurisdiction within the city or borough, with precedence next to the mayor. He holds once in every quarter of a year, or at such other and more frequent times as he shall in his discretion think fit, or as the crown shall think fit to direct, a court of quarter-session of the peace, at which he sits as the sole judge, such court being a court of record, and having cognisance of all crimes, offences, and matters whatever cognisable by any court of quarter-session of the peace for counties in England. No recorder has power to make or levy any rate in the nature of a county-rate, or to grant licence to keep an alehouse or victualling-house, to sell exciseable liquors, or to exercise any of the powers by that act specially vested in the town council.

The civil jurisdiction of the recorders of boroughs is exercised in the borough court, according to the charters or acts of parliament, if any, which regulate them. He may, however, delegate this duty to a judge of the court.

RECORDER, a musical instrument formerly in use; "a flageolet or small English flute, the mouthpiece of which, at the upper extremity of the instrument, resembled the beak of a bird; hence the larger flutes so formed were called *flutes à bec.* The recorder was soft in tone, and an octave higher than the flute. Milton speaks ('Par. Lost,' i. 550) of

> "The Dorian mood
> Of flutes and *soft recorders.*"

It would appear, from Bacon's 'Sylva Sylvarum,' cent. iii., 221, that this instrument was larger in the lower than in the upper part; and a wood-cut of the flageolet in Mersenne's 'Harmonie Universelle,' leads to the same conclusion. On the etymology of the word much ingenuity has been bestowed, but without any satisfactory result." (Note in 'Pict. Shaksp.,' Hamlet, Act iii., Sc. 2.)

RECORDS, PUBLIC. Authentic memorials of all kinds, as well public as private, may be considered in one sense as records. Thus the Metopes of the Parthenon are indisputable records of Grecian art; the journal stamp on a letter is a record that it has passed through the post-office; a merchant's letter is a record of his business; and every lord of a manor may keep written records of his courts, as the chancery, the exchequer, and other courts do of their proceedings. But our present purpose is to give some general account of the public records, properly so called, understanding by the term the contents of our Public Record Office.

Records, in the legal sense of the term, are contemporaneous satements of the proceedings in those higher courts of law which are distinguished as courts of record, written upon rolls of parchment. (Britton, c. 27.) Matters enrolled amongst the proceedings of a court, but not connected with those proceedings, as deeds enrolled, &c., are not records, though they are sometimes in a loose sense said to be "things recorded." In a popular sense the term is applied to all public documents preserved in a recognised repository; and as such documents cannot conveniently be removed, or may be wanted in several places at the same time, the courts of law receive in evidence examined copies of the contents of public documents so preserved, as well as of real records. [COURTS; RECORD; RECORDER.]

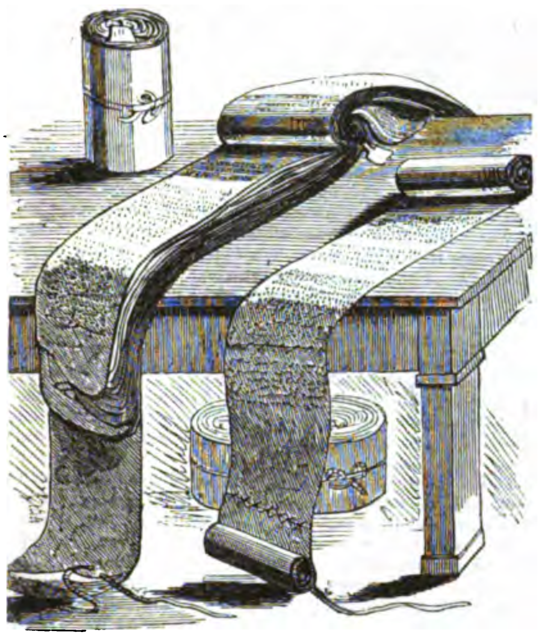
The course we propose to take, is to treat that as a record which is thus received in the courts of justice. The act, for instance, which abolished Henry VIII.'s court of augmentation (of the revenues obtained from the suppression of the religious houses), declared that its records, rolls, books, papers, and documents, should thenceforth be held to be records of the court of exchequer; and accordingly we have seen many a document, originally a mere private memorandum, elevated to the dignity of a public record, on the sole ground of its official custody, and received in evidence as a record of the Augmentation-office. On the other hand, numbers of documents which were originally compiled as public records, having strayed from their legal repository to the British Museum, have thereby lost their character of authenticity. ('Proceedings of the Privy Council,' vol. v., p. 4, edited by Sir Harris Nicolas.)

"Our stores of public records," says Bishop Nicolson, and, we believe, with perfect accuracy, "are justly reckoned to excel in age, beauty, correctness, and authority, whatever the choicest archives abroad can boast of the like sort." (Preface to the 'English Historical Library.')

By far the greater part of records are kept as rolls written on skins of parchment and vellum, averaging from nine to fourteen inches wide,* and about three feet in length. Two modes of fastening the skins or membranes were employed,—one, that of attaching all the tops of the membranes together bookwise, which is employed in the exchequer and courts of common law; the other, that of sewing each membrane consecutively, which was adopted in the chancery and wardrobe.

The solution of the reasons for employing two different modes has been thought difficult by writers on the subject. It appears to have been simply a matter of convenience in both cases. The difference in the circumstances under which these rolls were formed, accounts for the variation of make. In the first case, each inrolment was often begun at one time and completed at another. Space for the completion of the entry must have been left at hazard. Besides, several scribes were certainly engaged in inrolling the proceedings of the courts, and the roll was liable to be unbound, and to receive additional membranes after it had once been made up. In the other case, the business of the chancery being simply registration, the scribe could register the documents before him, with certainty that nothing in future would affect their length, and he was enabled to fill every membrane, and perfect the roll as he proceeded.

* The rolls of the Great Wardrobe exceed eighteen inches in width.



In the *volumina*, or *scapi*, of the ancients, the writing was carried in equal columns, as in the pages of a book, along the length of the skin, but the inrolment in both sorts of our rolls is written across the width of the membrane. The rolls of the common law, after the time of Henry VIII., contain so many skins that they cease to be rolls, but become simply oblong books, and, unlike the early rolls of the same series, are exceedingly ill-adapted for preservation and inconvenient for use. There are many of these miscalled rolls of the reign of Charles II., which in shape, size, and weight resemble the largest Cheshire cheese, often requiring two men to lift them from the rack. Membranes may be fastened together after the chancery fashion in any numbers, and yet remain a legitimate roll, though imposing much bodily labour in the consultation. The land-tax commissioners' Act of 1 Geo. IV. extends, it is said, 900 feet when unrolled. Other records have the shape of books. Doomsday Book, called both 'Rotulus' and 'Liber,' the oldest and most precious of our records, counting eight centuries as its age, and still in the finest order, is a book; and as occasions presented themselves for adopting this shape without infringing on ancient precedent, the far more accessible shape which we now call a "book" seems to have been employed. A considerable part of the records of the courts of the surveyor-general and augmentations, in the reign of Henry VIII., of wards and liveries, and requests, are made up as books. Other documents, those relating to fines, the 'Pedes Finium or Finales Concordiæ,' the writs of 'Dedimus Potestatem,' and acknowledgments and certificates, writs of the several courts and returns, writs of summons and returns to parliament, inquisitiones post mortem, &c., &c., by tens and hundreds of thousands are filed, that is, each document is pierced through with a string or gut, and thus fastened together in a bundle.

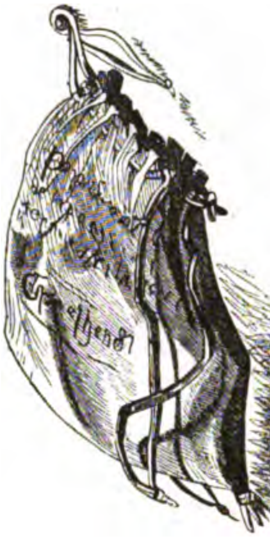
The material on which the record is written is generally parchment, which, until the reign of Elizabeth, is extremely clear and well prepared. From that period until the present, the parchment gradually deteriorates, and the worst specimens are furnished in the reigns of George IV. and William IV. The earliest record written on paper, known to the writer, is of the time of Edward II. It is one of a series entitled, 'Papirus magistri Johannis Guicardi contra-rotulatoris Magnæ Costumæ in Castro Burdegaliæ, anno domini M°. ccc°. viii°.' These records are in the office of the queen's remembrancer of the exchequer.

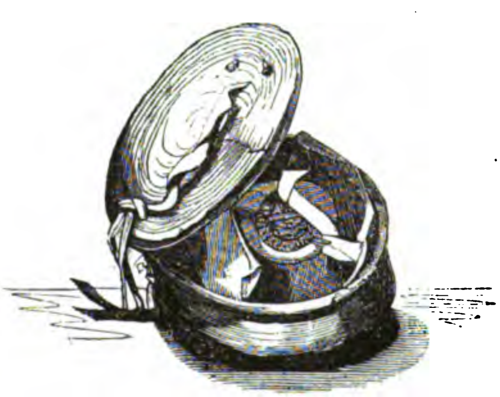
Tallies were records of wood. [TALLY.]

The handwriting of the courts, commonly called court-hand, which had reached its perfection about the reign of our second Edward, differs materially from that employed in chartularies and monastic writings. As printing extended, it relaxed into all the opposites of uniformity, clearness, legibility, and beauty which it once possessed. The ink too lost its ancient indelibility; and, like the parchment, both handwriting and ink are the lowest in character in the later times; with equal care, venerable Domesday will outlive its degenerate descendants.

All the great series of our records, except those of parliament, are written in Latin, the spelling of which is much abbreviated. The reader who desires to be further informed on the subject may consult the collections of contractions which Mr. Hardy has inserted in the preface to his 'Close Rolls of King John,' and Mr. Hunter, in his preface to the 'Fines of Richard I. and John.' During the Commonwealth, English was substituted; but soon after the Restoration, Latin was restored, and the records of the courts continued to be kept in Latin until the reign of George II. In certain branches of the exchequer, Latin continued in use until the abolition of the offices in very recent times. Many of our statutes from Edward I. to Henry V., and the principal part of the rolls of parliament, are written in Norman French. Petitions to parliament continued to be presented in Norman French until the reign of Richard II., whose renunciation of the crown is said to have been read before the estates of the realm at Westminster first in Latin and then in English. After this period we find English often used in transactions between the people and government, a sure sign that the distinctions of Norman origin were nearly absorbed among the people at large.

Sir Francis Palgrave's edition of the 'Calendars and Inventories of the Treasury of the Exchequer,' some of which were compiled as early as the 14th century, are extremely interesting in exhibiting the ancient modes in which records were preserved. No uniform system of arrangement seems to have been employed, but a different expedient was used for the preservation of nearly every separate document. Great numbers, judging from the quantity found in arranging the miscellaneous records of the queen's remembrancer of the exchequer, were kept in pouches or bags of leather, canvas, cordovan, and buckram, a mode which is still used in this department of the exchequer. These pouches, which fasten like modern reticules, are described by Agarde, who was keeper of the Treasury of the Exchequer, "as hanging against the walls." The following drawing represents a leathern pouch containing the tallies and the account of the bailiff of the manor of Gravesend in the 37 and 38 of Edward III.





When they have escaped damp, they have preserved their parchment contents for centuries in all their pristine freshness and cleanliness. Chests, coffers, coffins, and "forcers" bound with iron and painted of different colours, cases or "scrinia,"* "skippets," or small turned boxes, and hanapers, or "hampers of twyggys," were also used.

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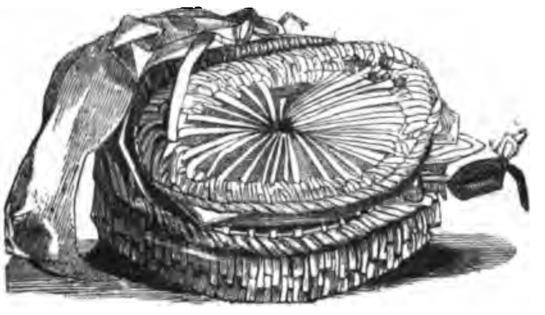
* The Romans kept their records in 'Scrinia,' respectively distinguished as 'Scrinia Viatoria; Scrinia Stataria; Scrinia Palatii; Scrinia Sacra; Scrinia Augusta.'



Inscriptions on labels, letters, and "signs" furnished the means of reference. We owe the following specimens of these "signs" to the kindness of Sir Francis Palgrave, who has obliged us with the loan of the blocks, cut for his calendars of the exchequer before mentioned. These signs in most cases bear analogy to the subject of the documents which they are intended to mark.

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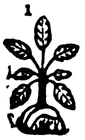

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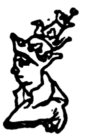

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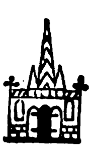

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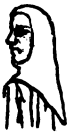

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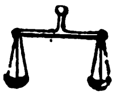

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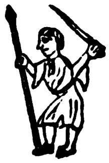

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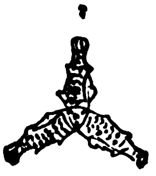

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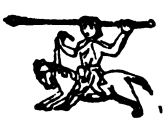

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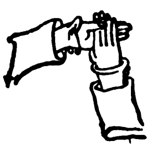

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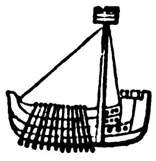

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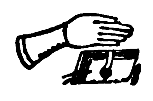

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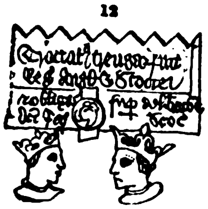

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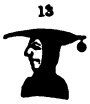

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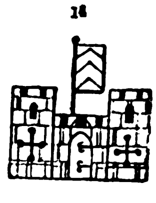

The rolls of the justices of the forest were marked by the sapling oak (No. 1). Papal bulls by the triple crown (2). Four canvas pouches holding rolls and tallies of certain payments made for the church of Westminster were marked by the church (3). The head in a cowl (4) marked an indenture respecting the jewels found in the house of the Fratres Minores in Salop. The scales (5), the assay of the mint in Dublin. The Briton having one foot shod and the other bare, with the lance and sword (6), marked the wooden "coffin" holding the acquittance of receipts from Llewellin, Prince of Wales. Three herrings (7), the "forcer" of leather bound with iron, containing documents relating to Yarmouth, &c. The lancer (8), documents relating to Aragon. The united hands (9), the marriage between Henry, Prince of Wales, and Philippa, daughter of Henry IV. The galley (10), the recognisance of merchants of the three galleys of Venice. The hand and book (11), fealty to kings John and Henry. The charter or cyrograph (12), treaties and truces between England and Scotland. The hooded monk (13), advowsons of Irish churches. And the castle with a banner of the Clare arms (14), records relating to the possessions of the earl of Gloucester in Wales.

Our ancestors before the Norman conquest pursued no system of public registration. There are numerous charters of the Anglo-Saxon kings and deeds between private individuals still existing: six volumes of these were edited by the late most able scholar, John Mitchell Kemble, under the title of 'Codex Diplomaticus ævi Saxonici, but even he did not exhaust the precious store. Historical events were chronicled in monastic chartularies.

The Anglo-Saxons, whose judicial proceedings were conducted orally, had no records except the "land-bocs" or charters. The transactions of the folk-moots were not registered or *recorded*, and in the administration of justice no reference was made to written precedents. In such a state of society, though the actual possession of land constituted one of the best titles to real property, still the "land-boc" furnished evidence of it also. And so important were these land-books considered, that when the monks of Ely purchased seven hydes and a half of land, they gave three hydes, besides thirty "aurei," to recover the charter or "cyrograph" of the title. Duplicates and triplicates of these land-books were made, and one "part" was delivered into the custody of the Burthegn, or chamberlain, to be preserved in the "horde," or royal treasury.

When a written account is made of any act, it is clear that it is made not for the exclusive benefit of one party only. In the Domesday Book of the Norman conqueror, we see evidence that his power was far from absolute. The financial registrations (Rotuli Pipæ) of Henry I., in whose reign the earliest example is found—the records of the judicial proceedings of the "Curia Regis," which begin with Richard I.—and the special acts of the monarch himself enrolled on the "close," "patent," and "charter" rolls commencing in the reign of John—are all so many irresistible proofs how larger interests were gradually trenching on the will of the king. The judicial records of the King's Bench and Common Pleas, and the parliamentary records beginning with Edward I., are further evidence of the increasing influence of the nobles and commonalty of the realm.

The king was legally considered as possessing the sovereign power. His peace was broken when the subject fell by the hand of the murderer; his parliament was to be summoned; his honour to be vindicated; and his army to be levied. It was the king's exchequer, the king's wardrobe, the king's court, and essentially the king's chancery; for the chancellor's functions were originally those of a private secretary, combining duties both spiritual and temporal. Holding the keepership of the king's conscience, the chancellor was necessarily of the clerical body, and the chief of the king's chapel. The great seal was in his custody, and the scope of his secretarial duties embraced all those of modern times performed by our secretaries of state for the home and foreign departments; and of all the business transacted a systematic and orderly registration was preserved in the several inrolments called "patent," "close," "charter," &c. All records of these several departments formed part of the king's treasure; and, in accordance with the practice of the ancient Persians five hundred years before the Christian era, when Darius caused a search for the decree of Cyrus to be "made in the house of the rolls, where the treasures were laid up in Babylon" (Ezra, vi. 1), were deposited in the king's "treasuries." [*] The mutual interest of all parties naturally made the preservation of the records an object of general solicitude; to the king, as they furnished indisputable precedents for his calls of military service and taxation; to the nobles, in protecting them in their feudal rights and various privileges; and to the commons most of all, in limiting the powers both of king and nobles, sheltering them from capricious extortion, and securing to them a certain amount of consistency in the administration of justice.

In Henry III.'s reign there were royal treasuries of records in the Tower of London and the New Temple. From the latter place, in the 20th of Edward I., out of a chest secured by nine keys, certain records of the Chancery were taken by the king's orders. ('Rot. Claus.,' 20 Edward I., m. 13 d.) The Tower had certainly become a permanent treasury for records in the 33rd of Edward I., when a transfer to it was directed to be made of all the papal privileges touching the crown or kingdom, from the treasury of the exchequer at Westminster. ('Rot. Claus.,' 33 Edward I., m. 3.) Another "treasury" is described by certain "memoranda," made 19 Edward III., as within the cloister of Westminster Abbey, near the Chapter-House (thesauraria Regis infra Claustrum Abbatiæ Westmonasterii juxta Capitulum). This "treasury" still remains. A single pillar supports the vaulted chamber, which is yet to be seen, with its double oak doors grated and barred with iron and locked with three keys, and its drawers and "tills" labelled by Arthur Agarde, who was custos of the records it contained. In his 'Compendium of the Records in the Treasury,' compiled 1610, he says that "the recordes of the kinge's majesties threasury at Westminster, under the custodie of the lord-threasurer and the two chamberlaines, were lay'd up for their better preservacion in fower severall threasauries under three severall kayes, kept by three sondry officers, distinct the one kay from another, and uppon each dore three lockes. The first in the Court of Receipt; the seacond in the Newe Pallace at Westminster, over the Little Gatehouse there; the third in the late dissolved abbey of Westminster, in the Old Chapter-House; the fourth in the cloister of the sayd abbey."

The contents of several "treasuries" at various periods seem to have been consolidated in the Chapter-House of Westminster Abbey, which was fitted up for the reception of records by Sir Christopher Wren.

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[*] Certain records of the Chancery followed the king in his migrations over the kingdom as late as Richard II. Religious houses were called upon to provide horses for the conveyance of them. Edward I., by writ, tested the 4th July, in the twenty-eighth year of his reign, commanded the abbot of Furness to provide a strong horse to carry the Chancery Rolls to York.

The demolition of the old "treasuries" adjoining Westminster Hall scattered their contents in all quarters of the metropolis. Thus the records of the king's remembrancer, of the Exchequer, and the Common Pleas, migrated from Westminster Hall to the late Mews at Charing Cross; and thence, to make room for the National Gallery, to Carlton Riding-School. The records of the late lord-treasurer's remembrancer and Pipe-Office were entombed two stories deep in the vaults of Somerset House. Those of the King's Bench for a time rested opposite St. Margaret's Church, but were shifted to the Roll's-House in Chancery Lane to make room for the present Rolls Court at Westminster.

Thus from time to time had repositories, as well undignified with the ancient title of "king's treasury" as deficient in that careful superintendence which originally accompanied the title, arisen in all parts of London; and in 1837 a Committee of the House of Commons reported that it had seen the Public Records, the most precious part of the king's "treasure," deposited at the Tower over a gunpowder-magazine, and contiguous to a steam-engine in daily operation; at the Rolls, in a chapel where divine service is performed; in vaults two stories underground at Somerset House; in dark and humid cellars at Westminster Hall; in the stables of the late Carlton Ride; in the Chapter-House of Westminster Abbey.

It would seem that as early as the commencement of the 14th century the officers charged with the custody of the records were found to be either insufficient or neglectful of the performance of their duties. Since the time of Edward II. scarcely a reign has passed without a special temporary agency being appointed to restore the public records to good order. The necessity probably arose from the functions of the officer charged with the care of the records being altogether changed, as in the instance of the master of the Rolls, who was the *bonâ fide* "gardein des roules" in early times.

In the 14th Ed. II., the barons of the Exchequer were directed to employ competent clerks to methodise the records, which were "not then so properly arranged for the king's and the public's weal as they ought to be." Again in the 19th year of Ed. II., certain commissioners were appointed for a similar purpose. In Edward III.'s reign, at least three like commissions were issued ('Rot. Claus.,' Annis 34 and 36; and 'Rot. Parl.,' Anno 46). Statutes for the protection of records from falsification, erasure, and embezzlement were passed 8 Rich. II. c. 4, and 11 Hen. IV. c. 3. Other measures were taken by Hen. VI., Hen. VII., and Hen. VIII. Inquiries into the state of the Parliamentary, the Chancery, and Exchequer Records were prosecuted by Queen Elizabeth, who also established the State Paper Office, in which the proceedings of the secretaries of state from her days to the present are preserved. Committees of both Houses of Parliament from time to time visited the several repositories, and the fire of the Cottonian Library in 1731 produced a report which describes the condition of most of the public repositories at that period. But the fullest examination into the state of the public records which has been made in recent times was effected by a Committee of the House of Commons, in 1800, conducted by Lord Colchester, then Mr. Abbot, and the report of that Committee presents by far the most perfect and comprehensive account which has yet appeared of our public records, to which a period of sixty years has added very little. This Report originated a commission for carrying on the work which its authors had begun. The Record Commission was renewed six several times between the years 1800 and 1831, and was altogether suspended at the accession of Her Majesty Queen Victoria. All the several record commissions recited, one after another, that "the public records of the kingdom were in many offices unarranged, undescribed, and unascertained;" that they were exposed "to erasure, alteration, and embezzlement," and "were lodged in buildings incommodious and insecure." The commissioners were directed to cause the records to be "methodised, regulated, and digested," bound and secured; to cause "calendars and indexes" to be made and "original papers" to be printed; but the record commissioners expended the funds entrusted to them rather in printing records than in arranging or calendaring them. A very full investigation into the proceedings of the record commission was made by a Committee of the House of Commons in 1835, and the reader who is curious to know more than our space allows us to state, may consult its Report, and the series of Reports since made by the Deputy Keeper of Public Records, which are published annually. Certainly during the present century there has been no niggard expenditure in one shape or another in respect of the public records. It is not very easy to ascertain its total amount, but the following may be received as an approximation up to the year 1839:—

Parliamentary Papers show that grants were made on behalf of the Record Commission between 1800 and 1831, to the amount of	£362,400
Between 1831 and 1839 inclusive	125,700
Salaries, &c., for the custody of Records	120,000
Fees, estimated on an average of the years 1829, 1830, and 1831, at least	120,000
Removals of Records, estimated at	30,000
	758,100
Irish Record Commission, estimated at	120,000
	£878,100

A very important step was taken by the legislature at the commencement of her Majesty's reign to provide for the better custody and preservation and more convenient use of the public records, and an act was passed (1 & 2 Vict., c. 49) calculated to remedy effectually what preceding efforts had in vain attempted, by constituting a special agency for the custody of the records; to the want of which and a sufficient responsibility, all the defects of the old system are attributable. By this act the Master of the Rolls is made the guardian of the public records, having powers to appoint a deputy, and, in conjunction with the treasury, to do all that may be necessary in the execution of this service. The act contemplates the consolidation of all the records, from their several unfit repositories, into one appropriate receptacle; their proper arrangement and repair; the preparation of calendars and indexes, which are more or less wanting to every class of records; and giving to the public more easy access to them. Lord Langdale, the late master of the rolls, to whose influence the change of system is greatly due, brought the above act into as full operation as circumstances allowed while he lived; and his successor, the Right Hon. Sir John Romilly, has, with untiring patience, watched and fostered the collection of the Public Records into the costly building now erected near Fetter Lane, where almost any document of public interest may be consulted gratis by the literary inquirer, and by the legal profession for legal purposes under the following regulations and fees.

Extract from the Regulations made by the Right Honourable the Master of the Rolls, concerning the gratuitous admission of literary inquirers to the Public Records, including the State Papers.—July 5, 1858.

That the individuals seeking to avail themselves of the permission, shall address a letter to the deputy keeper, stating generally their objects of research, and that the applicant shall also, if needful, attend the deputy keeper personally thereon, and give such further explanation as may be required; and that thereupon the deputy keeper shall, if satisfied with the statement and explanation, issue a permission empowering the applicant or any trustworthy agent or transcriber on his behalf, to inspect all indexes of records, and original records, and also to make copies or extracts, without payment of fees. It will be necessary also to explain to applicants that the literary inquirer will have free access to the documents; but, this being done, he will have to conduct the inquiry in such manner as his own knowledge and experience may best enable him to do.

Fees.

	£	s.	d.
I. For searching calendars, indexes, or other books of reference, each day	0	1	0
II. For inspection of any document, each day	0	1	0
" of any number of documents above five, each day	0	5	0
Any roll, book, portfolio, file, or bundle, to be considered as one inspection.			
The inspection fee will be remitted when a copy is ordered *at the time of inspection.*			
III. For copies, at 72 words each folio:—			
Under three folios	0	2	0
Three folios and upwards, each folio	0	0	9
All copies are to be authenticated.			
IV. For attendance at either house of parliament, to be sworn	1	1	0
For attendance at either house of parliament, or elsewhere, to give evidence; or with ten records or less number: each day	2	2	0
Ditto, ditto, for each additional record, each day	0	2	0
For attendance on the Master of the Rolls on a vacatur	1	1	0

We can only find space to glance at the particular classes of the public records, noticing in the fewest words the more ancient and valuable. No enumeration we could give would enable the reader to dispense with reference to the inventories, repositories, calendars, catalogues, and indexes which are printed, or those existing in manuscript in the various branches of the record office. The best work of general reference is the 'Report of the Select Committee in 1800,' from which we have taken a brief analytical list of the subjects to which the public records relate. Though this list is not altogether what is to be desired, it is the best within moderate limits that we know of, and is sufficient to prove that there is perhaps no branch of the public administration of our country which is destitute of its authentic memorials. It was compiled by Mr. Luders, and is printed in the above Report.

ENGLAND.

I. *The King, Royal Family, and Household.*

1. The King. 2. The Queen. 3. The Prince of Wales. Household. Privy Seals and Correspondence. Principality of Wales. Duchy of Cornwall. 4. Custos Regni, Lieutenant, Protector, Regent, Lord Justices. 5. Household. 6. The King's Chamber.

II. *The Royal Councils.*

1. Parliament. The House of Lords. The House of Commons. 2. Privy Council.

III. *The Royal Prerogative.*

1. In Ecclesiastical Affairs. Before and after the Reformation. Proceedings of the Commonwealth. 2. In Civil Affairs. General Administration of the Realm. Honours and Offices. Trade and Coin. 3. In Military and Naval Affairs. 4. In Foreign Affairs.

IV. *The Royal Revenues.*

1. Ordinary. Land Revenues. Casual Revenues. 2. Extraordinary.

V. *Courts of Justice.*

1. Of Abolished or Obsolete Jurisdiction. Curia Regis. Placita de Assisis. Placita Itineraria. Placita Forestæ. Placita Coronæ. Placita Aulæ. Placita de Quo Warranto. Star Chamber Proceedings. Court of Requests. Court of Wards and Liveries. Court of Augmentations. Surveyor-General's Court. Court of Chivalry: namely, Constable and Marshal. 2. Of Occasional Jurisdiction. Special Commissions. Court of Judicature for determining Differences after the Fire of London. High Court of Justice. 3. Of Established Jurisdiction. Chancery. Its ordinary and Extraordinary Jurisdiction. King's Bench. Pleas of the Crown and in Civil Suits. Common Pleas. Exchequer of Account—The Queen's Remembrancer's Office. The Lord Treasurer's Remembrancer's Office. Exchequer of Receipt—Tellers, Tally Court, Auditor or Tally Writer, Pell Office, Auditors of Imprest, Commissioners for auditing the Public Accounts. Exchequer of Pleas and of Error. Marshalsea and Palace Courts. Session of Oyer and Terminer and Gaol Delivery for London, and Gaol Delivery for Middlesex. Great Sessions of Wales. Duchy of Lancaster. Counties Palatine. Stannary Courts. Cinque Ports. Commissioners of Sewers. Quarter-Sessions and Clerks of the Peace. Maritime Courts.—Admiralty Instance Court, Admiralty Prize Court, Court of Appeal in Prize Causes. Ecclesiastical Jurisdiction—Archiepiscopal, Episcopal, Appellate Jurisdiction, Deans and Chapters. Courts for offences in India.

VI. *Universities and Colleges, Schools, &c.*

1. Universities and Colleges. 2. Royal Schools, Chauntries, Hospitals, Colleges, Free Chapels, Fraternities, and Guilds.

VII. *Alienation of Private Property.*

SCOTLAND.

1. *The King.*

Title, Great Seal, Privy Seal, Signet, Chancery, Revenues, and Expenses. Acts of Civil Government. Ecclesiastical Government. 2. Parliament. 3. Privy Council. 4. General Registers. 5. Courts of Justice. Court of Session. Justiciary Court. Court of Exchequer. Admiralty Court. Commissary Courts. Court of Teind. Sheriff Court. 6. Universities.

IRELAND.

The Principal Record Repositories in Dublin are the *Bermingham Tower*, which contains Plea Rolls, Pipe Rolls, Summonisters' Rolls, Sheriffs' Tot Rolls, &c.; the *Parliamentary Record Office;* the *Rolls Office;* the Statute Rolls from Hen. V. to the Union; Patent and Close Rolls from 31 Ed. I. to the present time; Inquisitions post Mortem; Fiants from 21 Hen. VIII. to the present time: Decree Rolls; Recognisance Rolls from 21 Hen. VIII.; the *Chief Remembrancer's Office*, Memoranda Rolls from 6 Ed. I. to the present time; the *Auditor-General's Office*, Rolls of Public Accounts from Hen. VIII.; the Receiver-General, Vice-Treasurer's, Pell's, and Chamberlain's Books, the Debenture Exchequer Bills, and other Loan Books, the Vouchers of Public Accounts, the Collector's Accounts from every district in Ireland; the Quit-Rent Receipt Books, the Sheriffs' Accounts, with some Ancient Accounts of the Hanaper, First Fruits, Farmers of Revenue, Subsidies, Poll Tax, &c. The *Prerogative Office;* the *First Fruits Office; Surveyor-General's Office.* (*Reports of the Commissioners on the Public Records of Ireland.*)

The most important Public Records may be enumerated as follows:—

Great Roll of the Exchequer, from Hen. II., 1154—1833.

Exchequer—Lord Treasurer's, and Pipe Office, 2 Hen. II.—1833; with Memoranda Rolls, originalia Rolls, and various other enrolments, 1 Hen. III.—1833.

Exchequer—King's Remembrancer—Memoranda Rolls, and various classes of the Exchequer equity business, 1 Hen. III.—1841, when the business was transferred to the Court of Chancery.

Exchequer—First Fruits and Tenths, certificates of Institutions to Livings, 1558—present time; and various other classes, Hen. VIII. to present time.

Exchequer—Court of Augmentations, Ministers' account of Crown lands, and lands in the hands of the Crown, 27 Hen. VIII.,—1 Mary, when the Court was abolished.

Exchequer—Ministers' Accounts, 1 Mary—Chas. II.; and various other classes, Hen. VIII.—1649.

Exchequer—Pleas or Judgment Rolls, and various classes of Records of the Court, 1293 to present time; from 1830, including the business of the abolished Welsh Courts.

Comptroller's or Chancellor's Roll, 11 Hen. II—1833 (now deposited in the British Museum).

Rotuli Curiæ Regis, Ric. I., 1194—Hen. III., 1216.

Fines, Concords, Writs of Covenant, Feet of Fines, &c., 25 Hen. II., 1179—Wm. IV., 1833.

Charter Rolls, John, 1199—Hen. VIII., 1509.

Norman Rolls, John, 1200—Hen. V., 1412.

Patent Rolls, John, 1201—present time.

Close Rolls, John, 1204—Geo. II., 1727.

Liberate Rolls, John, 1200—Edw. IV., 1460-1.

Fine Rolls, John, 1204—Chas. I., 1625.

French Rolls, Hen. III., 1232—Edw. IV., 1460-1.

Gascon Rolls, Hen. III., 1242—Hen. VI., 1422.

Scotch Rolls, Edw. I., 1291—Edw. IV., 1460-1.

Roman Rolls, Edw. I., 1305—Edw. IV., 1460-1.

Statute Rolls (afterward the Parliament Rolls), Edw. I., 1277—Edw. IV., 1460-1.

Rolls of Parliament, Edw. I., 1272—Ric. III., 1483; Statutes, Hen. VII., 1485 to present time.

Petitions in Parliament, Edw. I., 1272—Edw. IV., 1460.

Journals of the House of Lords, Hen. VIII., 1509 to present time.

Journals of the House of Commons, Hen. VIII., 1509.

Summons and Returns to Parliament, Edw. I., 1288—Hen. VI., 1422; 33 Hen. VIII.—present time.

Original Acts of Parliament, 12 Hen. VII.—present time.

Inquisitiones post Mortem, or Escheats, Hen. III., 1216—Chas. I., 1625.

Inquisitiones ad quod damnum, Edw. II., 1307—Hen. VI., 1422.

Coronation Rolls, Edw. II., 1307—(series imperfect)—Geo. II., 1727.

Treaty Rolls (irregular series), Edw. V., 1483—James II., 1684-5.

Confirmation Rolls, Ric. III., 1483—Commonwealth, 1649.

Dispensation Rolls, 37 Eliz.—Geo. II., 1727.

Rolls of Pardons, Ric. III., 1483—Eliz., 1558.

Judgment or Decree Rolls of Chancery, 25 Hen. VIII.—present time.

Court of Chancery, various classes, from John to the present time.

Surrender and Specification Rolls, Chas. II., 1648-9—present time.

Privy Seals and Signet Bundles, Bills, and Writs, Edw. I., 1272—present time.

Signed Bill Bundles, Hen. VII., 1485—present time.

King's Bench Judgments, &c. inrolled, Edw. I., 1272—present time.

King's Bench—Crown side, Curia Regis and Coram Rege, or Crown Rolls, 5 Ric. I., to present time; Controlment Rolls, 1 Edw. III.—1844; various other classes from James I. to present time.

King's Bench—Plea side; before 1702, see Coram Rege; various classes of Records of the Court, from 1700 to present time.

Common Pleas—Plea or Judgment Rolls, and Placita terræ, and various classes of Records of the Court, Hen. III. to present time; for prior records see Curia Regis.

Pleas of the Forest, Hen. III., 1216—James II., 1684-5.

Miscellaneous Records of the King's Remembrancer, Ric. I., 1189—Geo. III., 1760.

Placita de Assisis, 6 Ric. I.—Edw. V., 1483.

Court of Wards and Liveries, Hen. VIII.—Chas. II., when the Court was abolished.

Star Chamber Court—3 Hen. VII.—16 Chas. I., when it was abolished.

Wales—various Courts, abolished 1830; various classes, Hen. III.—1830.

The preceding list exhibits generally, with a few exceptions hereafter noticed, the commencement of the chief and most valuable of our national records, and the periods over which they extend, from the time of Richard I., the boundary of "legal memory."

In the above list we have not included Domesday Book, the choicest of all our record treasures, and the corner-stone of our topographical history. The record itself has been most faithfully printed, and copiously described by Sir Henry Ellis. [DOMESDAY BOOK.] There are two abridgments of Domesday Book among the exchequer records, made probably about the time of Henry III. Subsequent territorial surveys, the Hundred Rolls, Extenta Manerii, Testa de Nevill, Pope Nicholas' Taxation temp. Edw. I., the Domesday of Wales, and Nonæ Rolls temp. Edw. III., King Henry VIII.'s Surveys, and Parliamentary Surveys of the Commonwealth, are excluded, because they form no consecutive series like the above.

The Great Roll of the Exchequer, or Pipe Rolls, or Rotuli Annales, being yearly accounts of the king's revenue, are conjectured to have begun with the Conqueror. Some evidence exists to establish that they probably extended over the whole reign of Henry I., though we know at present but of a single roll, the thirty-first year of that reign, which the Record Commission published under the editorship of Mr. Hunter. Excepting the rolls for the 1st of Henry III. and 7 Henry IV., the series from the 2nd of Henry II. is complete. Madox speaks of them as "Recorda omnium quæ in Archivis Regis usquam me memini, splendidissima, post Rotulum censualem quem Librum Domesday vocant; quin ei æquiparanda."

The series of Fines, being records of the transfer of lands, &c., extends unbroken, and almost unchanged in form, from the 25 Henry II. to the end of the year 1833, when this species of conveyance was abolished. [FINES.] Since the 16 Edward I. they have been delivered from time to time into the 'treasury' of the exchequer. Those in the Chapter-house and those lately kept by the Custos Brevium of the Common Pleas will shortly be united, and will present a series of records, like the Pipe Rolls and Rolls of the Curia Regis, unrivalled in all Europe. The Cartæ Antiquæ, formerly in the Tower, are transcripts of charters descending from the Saxon times to Henry III. They are hardly to be considered as part of the splendid series of chancery rolls commencing in King John's reign. In noticing the chancery rolls it is quite superfluous to do more than refer the reader to the prefaces which Mr. Thomas Duffus Hardy has attached to his editions of the earliest close and patent rolls. If we were to continue to particularise documents of age and interest, such as the Norman pipe-roll of Henry I., the 'Rotulus de Dominabus, temp. Henry II.' (which was printed by Mr. Stacey Grimaldi, in 1830), the Red Book of the Exchequer, containing the laws of the Conqueror and those ascribed to Henry I. (which has been fully catalogued by Mr. Hunter, in the 'General Report of Commissioners on Public Records,' 1837, p. 165), the Missæ and Præstita rolls of King John, or the Magnæ Chartæ of our kings, which were not inrolled in a systematic series until 1278, we should never conclude the subject. We therefore refrain from further specifications, and conclude this article with lists of the various publications lately issued by the Record Commissioners, and at present proceeding under the direction of the Right Honourable Sir John Romilly.

1. Domesday Book: seu Liber censualis Willielmi Primi, Regis Angliæ.
   Domesday Book, 2 vols. folio, 1783.
   Additamenta, consisting of the Exon Domesday, Inquisitio Eliensis, the Winton Domesday and the Boldon Book, and Indices, 2 vols. folio, 1816.
2. Statutes of the Realm, 9 vols. fol.; Alphabetical Index, 1 vol.; Chronological Index, 1 vol.: in all eleven volumes.
3. Fœdera, Conventiones, Litteræ, et cujuscunque generis Acta Publica, inter reges Angliæ, et alios quosvis Imperatores, Reges, Pontifices, Principes vel Communitates (being a new edition of Rymer's Fœdera).
4. Calendarium Rotulorum Patentium in Turri Londinensi (from John to Edward IV.), 1 vol. fol.
5. Calendarium Rotulorum Chartarum et Inquisitionum ad quod damnum (from John to Henry VI.), 1 vol. fol.
6. Calendarium Inquisitionum ad quod damnum (from 1 Edward II. to 38 Henry VI.).
7. Placitorum in domo Capitulari Westmonasteriensi asservatorum abbreviatio, temporibus regum Ric. I., Johannis, Hen. III., Edw. I. et Edw. II., 1 vol. fol.
8. Testa de Nevill; sive liber Feodorum in Curia Scaccarii, temp. Hen. III. et Edw. I., 1 vol. fol.
9. Rotulorum Originalium in curia Scaccarii abbreviatio temporibus regum Hen. III., Edw. I., II., et III., 1 vol. fol.
10. The Parliamentary Writs, and Writs of Military Summons; together with the Records and Muniments relating to the suit and service due and performed to the King's High Court of Parliament and the Councils of the Realm, or affording evidence of attendance given at Parliaments and Councils, vol. i.; vol. ii. divisions 1 and 2 and 3, fol.
11. Rotuli Hundredorum, temp. Hen. III. et Edw. I. in Turri Lond., et in Curia Receptæ Scaccarii Westm. asservati, 2 vols. fol., 1812.
12. Placita de Quo Warranto, temporibus Edward I., II., et III., in Curia Scaccarii Westm. asservata, 1 vol. fol., 1818.
13. Calendarium Inquisitionum post Mortem, sive Escaetarum, 4 vols. fol. (from Henry III. to Edward IV.).
14. Nonarum Inquisitiones in Curia Scaccarii temp. Regis Edwardi III., 1 vol. fol.
15. Taxatio Ecclesiastica Angliæ et Walliæ, Auctoritate P. Nicholai IV., circa A.D. 1291, 1 vol. folio.
16. Valor Ecclesiasticus, temp. Henry VIII., Auctoritate Regia institutus, 6 vols., folio.
17. Calendars of the Proceedings in Chancery in the Reign of Queen Elizabeth; to which are prefixed Examples of earlier Proceedings in that Court, namely, from the Reign of Richard II. to that of Queen Elizabeth inclusive, from the originals in the Tower, 3 vols., folio.
18. Ducatus Lancastriæ Pars Prima:—Calendarium inquisitionum post Mortem, &c., temporibus Regum Edw. I., Edw. III., Ric. II., Hen. V., Hen. VI., Edw. IV., Hen. VII., Hen. VIII., Edw. VI., Regin. Mar., Phil. et Mar., Eliz., Jac. I., Car. I.
   Pars Secunda:—A Calendar to the Pleadings, &c., in the reigns of Henry VII., Henry VIII., Edward VI., Queen Mary, Philip and Mary, and Elizabeth, 3 vols., fol.
19. A Catalogue of the Manuscripts in the Cottonian Library deposited in the British Museum, I vol., folio, 1802.
20. A Catalogue of the Harleian Manuscripts in the British Museum, 4 vols., fol., 1808-1812.
21. A Catalogue of the Lansdowne Manuscripts, 1 vol., fol.
22. The Acts of the Parliament of Scotland, 11 vols.; from 1424 to 1707.
23. Registrum Magni Sigilli Regum Scotorum, in Archivis Publicis asservatum, A.D. 1306-1424, 1 vol. fol., 1814.
24. Rotuli Scotiæ in Turri Londinensi, et in Domo Capitulari Westmonasteriensi asservati, 2 vols., fol.
25. Inquisitionum ad Capellam Domini Regis retornatarum quæ in Publicis Archivis Scotiæ adhuc servantur Abbreviatio, 3 vols., fol.
26. A General Introduction to Doomsday Book, 2 vols., 8vo.
27. Rotulus Litterarum Patentium 7 John: Transcripta Litt. Pat. Hiberniæ, temp. Hen. V. and VI. Placita 52 Hen. III., 8vo.
28. Rotuli Litterarum Clausarum ab anno 1204 ad annum 1224, 1 vol.
29. Rotuli Litterarum Patentium A.D. 1201-1216, fol.
30. The Chancellor's Roll, or Antigraph of the Great Roll of the Pipe, 3 John, 8vo.
31. Rotulus Magnus Pipæ de anno 31 Henrici I., commonly called the Roll of Stephen, 8vo.
32. Proceedings and Ordinances of the Privy Council in the reigns of Richard II., Henry IV., V., VI., 7 vols., 8vo.
33. Rotuli Normanniæ: John and Henry V., 8vo.
34. Excerpta e Rotulis Finium; Henrici III., 2 vols., 8vo.
35. Rotuli de Oblatis et Finibus; John, 1 vol., 8vo.
36. Fines sive Pedes Finium, sive finales Concordiæ in Curiâ Domini Regis, A.D. 1195-1214, 8vo.
37. Rotuli Curiæ Regis Ric. I. et Johan, 2 vols., 8vo.
38. An Account of the most important Records of Great Britain, by C. P. Cooper, 2 vols., 8vo.
39. Selections from the Miscellaneous Records of the King's Remembrancer of the Exchequer, 8vo.
40. Ancient Inventories and Calendars of the Treasury of the Exchequer, from Edward III. to Henry VIII., 3 vols., 8vo.
41. Documents elucidating the Ancient History of Scotland, Alexander III. to Robert I., 1 vol., 8vo.
42. The Charter Rolls of John, 1 vol., fol.
43. Ancient Laws and Institutes of England, comprising laws enacted under the Anglo-Saxon kings from Æthelbert to Canute, with an English translation of the Saxon; the laws called Edward the Confessor's; the laws of William the Conqueror; and those ascribed to Henry I. Also Monumenta Ecclesiastica Anglicana, from the 7th to the 11th century; and the ancient Latin version of the Anglo-Saxon Laws, 1 vol., fol., 1840, and
44. Monumenta Historica Britannica, 1 vol., fol., 1848.

The printing of other works was in progress when the Record Commission dropped. See 'Report on the Record Commission, App.,' p. 782.

State Papers preserved in the State Paper Department of the Public Record Office, published in imp. 8*vo, price* 15*s. each volume.*

Calendar of State Papers, Domestic series, of the Reigns of Edward VI., Mary, Elizabeth, 1547–1580. Edited by Robert Lemon, Esq., F.S.A. 1856.

Calendar of State Papers, Domestic Series, of the Reign of James I. Edited by Mary Anne Everett Green. 1857–1859. In 4 vols., from 1603 to 1625.

Calendar of State Papers, Domestic Series, of the Reign of Charles II. Edited by Mary Anne Everett Green. 1860. A second volume is in the press.

Calendar of State Papers, Domestic Series, of the Reign of Charles I. Edited by John Bruce, Esq., V.P.S.A. 1858–1859. Three vols.; a fourth volume is in the press.

Calendar of State Papers relating to Scotland. Edited by Markham John Thorpe, Esq., Oxford. 1858. In 2 vols., from 1509 to 1587.

Calendar of State Papers relating to Ireland, 1509–1573. Edited by H. C. Hamilton, Esq., F.S.A. 1860. Vol. II. is in the press.

Calendar of State Papers, Colonial Series. Edited by W. Noël Sainsbury, Esq. 1860. A second volume is in the press; as also are—

Calendar of State Papers of the Reign of Henry VIII. Edited by the Rev. J. S. Brewer, M.A.

Calendar of State Papers, Foreign Series, of the Reign of Edward VI. Edited by W. B. Turnbull, Esq.

There have been also published, in royal 8*vo, price* 8*s.* 6*d. per volume, the Chronicles and Memorials of Great Britain and Ireland during the Middle Ages.*

1. The Chronicle of England, by John Capgrave. Edited by the Rev. F. C. Hingeston, M.A.
2. Chronicon Monasterii de Abingdon. Vols. I. and II. Edited by the Rev. J. Stevenson, M.A.
3. Lives of Edward the Confessor. I.—La Estoire de Seint Aedward le Rei. II.—Vita Beati Edvardi Regis et Confessoris. III.—Vita Æduuardi Regis qui apud Westmonasterium requiescit. Edited by H. R. Luard, M.A.
4. Monumenta Franciscana; scilicet, I.—Thomas de Eccleston de Adventu Fratrum Minorum in Angliam. II.—Adæ de Marisco Epistolæ. III.—Registrum Fratrum Minorum Londoniæ. Edited by the Rev. J. S. Brewer, M.A.
5. Fasciculi Zizaniorum Magistri Johannis Wyclif cum Tritico. Ascribed to Thomas Netter, of Walden, Provincil of the Carmelite

Order in England, and Confessor to King Henry the Fifth. Edited by the Rev. W. W. Shirley, M.A.

6. The Buik of the Croniclis of Scotland; or, A Metrical Version of the History of Hector Boece; by William Stewart. Edited by W. B. Turnbull, Esq. In 3 volumes.

7. Johannis Capgrave Liber de Illustribus Henricis. Edited by the Rev. F. C. Hingeston, M.A.

8. Historia Monasterii S. Augustini Cantuariensis, by Thomas of Elmham, formerly Monk and Treasurer of that Foundation. Edited by C. Hardwick, M.A.

9. Eulogium (Historiarum sive Temporis), Chronicon ab Orbe condito usque ad Annum Domini 1366; a Monacho quodam Malmesbiriensi exaratum. Vol. I. Edited by F. S. Haydon, Esq., B.A. Two other volumes are in the press.

10. Memorials of King Henry the Seventh: Bernardi Andreæ Tholosatis de Vita Regis Henrici Septimi Historia; necnon alia quædam ad eundem Regem Spectantia. Edited by J. Gairdner, Esq.

11. Memorials of Henry the Fifth. I.—Vita Henrici Quinti, Roberto Redmanno auctore. II.—Versus Rhythmici in laudem Regis Henrici Quinti. III.—Elmhami Liber Metricus de Henrico V. Edited by C. A. Cole, Esq.

12. Munimenta Gildhallæ Londoniensis; Liber Albus, Liber Custumarum, et Liber Horn, in archivis Gildhallæ asservati. Vol. I., Liber Albus. Vol. II. (in Two Parts), Liber Custumarum. Edited by H. T. Riley, Esq., M.A.

13. Chronica Johannis de Oxenedes. Edited by Sir H. Ellis, K.H.

14. A Collection of Political Poems from the Accession of Edward III. to the Reign of Henry VIII. Vol. I. Edited by T. Wright, Esq., M.A. A Collection of Political Prose for the same period is also in the press.

15. The 'Opus Tertium' and 'Opus Minus' of Roger Bacon. Edited by the Rev. J. S. Brewer, M.A.

16. Bartholomæi de Cotton, Monachi Norwicensis, Historia Anglicana (A.D. 449–1298). Edited by H. R. Luard, M.A.

17. The Brut y Tywysogion, or, The Chronicle of the Princes of Wales. Edited by the Rev. J. Williams ab Ithel.

18. A Collection of Royal and Historical Letters during the Reign of Henry IV. Vol. I. Edited by the Rev. F. C. Hingeston, M.A. A second volume is in the press.

19. The Repressor of over much Blaming of the Clergy. By Reginald Pecock, sometime Bishop of Chichester. Vols. I. and II. Edited by C. Babington, B.D.

20. The Annales Cambriæ. Edited by the Rev. J. Williams ab Ithel.

In the Press.

Ricardi de Cirencestria Speculum Historiale de Gestis Regum Angliæ. (A.D. 447–1066). Edited by J. E. B. Mayor, M.A.

The Anglo-Saxon Chronicle. Edited by B. Thorpe, Esq.

Le Livere de Reis de Brittanie. Edited by J. Glover, M.A.

Recueil des Croniques et Anchiennes Istories de la Grant Bretaigne a present nomme Engleterre, par Jehan de Waurin. Edited by W. Hardy, Esq.

The Wars of the Danes in Ireland: written in the Irish language. Edited by the Rev. Dr. Todd.

Original Letters and Papers illustrative of the History of England during the Fifteenth Century. Edited by the Rev. J. Stevenson, M.A.

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Letters and Papers of the Reigns of Richard III. and Henry VII. Edited by James Gairdner, Esq.

Munimenta Gildhallæ Londoniensis; Liber Albus, Liber Custumarum, et Liber Horn, in Archivis Gildhallæ asservati. Vol. III. Translations from the Anglo-Norman portions of the Liber Albus; Appendix; Glossaries; and Index. Edited by H. T. Riley, Esq., M.A.

Descriptive Catalogue of Manuscripts relating to the Early History of Great Britain. Edited by T. Duffus Hardy, Esq.

In progress.

Historia Minor Matthæi Paris. Edited by Sir F. Madden.

Letters and Treatises of Bishop Grosstete, illustrative of the Social Condition of his Time. Edited by the Rev. H. R. Luard, M.A.

Chronicon Abbatiæ Eveshamensis, Auctoribus Dominico Priore Eveshamiæ et Thoma de Marleberge Abbate, a Fundatione ad Annum 1213, una cum Continuatione ad Annum 1418. Edited by the Rev. W. D. Macray, M.A.

A Roll of the Irish Privy Council of the 16th year of the Reign of Richard II. Edited by the Rev. James Graves.

Polychronicon Ranulphi Higdeni, with Trevisa's Translation. Edited by C. Babington, B.D.

RECOVERY, COMMON. A common recovery was a judgment in a fictitious suit, in which the tenant of the freehold was the defendant; and the judgment was given in consequence of default made by the person who was last vouched, that is, summoned to warranty in such suit. It was used for the purpose of barring estates tail and all remainders and reversions expectant thereon.

A common recovery was in the form of a judgment obtained in a real action, and accordingly the mode of proceeding was the same as in an action not fictitious. The plaintiff in the action, or demandant, who sought to recover the lands, sued out a writ or præcipe, as it was called, from the words of the writ (Præcipe A, the tenant, quod juste, &c. reddat B, the lands in question) against the person who had the freehold of the estate, and who was called the tenant to the præcipe. He appeared to the writ; but instead of defending his title, he vouched (vocavit) some other person who was supposed to be bound to warrant the tenant's title, and he prayed that the person so vouched (the vouchee) might defend the title so warranted, or that, if he could not, he might give the tenant lands of equal value with those which he might lose by failure of the warranty. The vouchee, having appeared, undertook the defence of the tenant's title, but he purposely failed to do so, and on his default the court gave judgment, which was that the demandant or recoverer should recover the lands against the tenant, and that the tenant should recover against the vouchee lands of equal value. Such lands were called the recompense or recovery in value. By the first judgment the demandant obtained the fee simple of the estate. The whole proceeding being a fiction, it was usual to make the common crier of the Court of Common Pleas the vouchee, who was hence called the common vouchee. This proceeding was called recovery with single voucher; but there might be recovery with double or treble voucher, in which case judgment was given against the several vouchees. Where an estate tail was to be barred, there was double voucher, the tenant in tail conveying an estate of freehold to some person, against whom the demandant brought the præcipe, who then vouched the tenant in tail, who vouched over the common vouchee, who of course made default, and judgment was accordingly given for the demandant against the tenant to the præcipe, for the tenant to the præcipe against the tenant in tail, and for him against the common vouchee.

On judgment being given, a writ of *habere facias seisinam* was sued out, which, though not executed, was returned as if it had been, and the recovery was then complete.

A defect in any one of the proceedings might vitiate the recovery. One of these circumstances of the greatest practical importance was the making a good tenant to the præcipe; for unless the person against whom the writ was brought was actual tenant of the freehold, there could be no good recovery. It was however sufficient if he acquired the freehold at any time before judgment was given in the suit; and by 14 Geo. II., c. 20, § 6, it was sufficient if he acquired the freehold after judgment and the award of the writ of execution.

It was usual for the tenant in tail to be vouched in recovery to bar estates tail, because the validity of the recovery was founded on the doctrine that the estate which the tenant in tail obtained by virtue of the warranty in lieu of that which he lost by the vouchee's default, would descend to the heirs in tail, just as the estate would have done which the tenant in tail had lost. It is true that the recompense could not extend to the person entitled to the reversion, nor to contingent interests; but this defect, which would have been fatal if the transaction had been real, was never considered to impair the efficacy of the fictitious proceeding. And it was a settled principle that the estate obtained by way of recompense would only follow the course of descent of that estate of which the tenant in tail was seised at the time of the recovery; and therefore if the tenant in tail at the time of the recovery was not seised of an estate tail according to the form of the original gift, the recompense in value would descend according to the estate which he had at the time of the recovery, and not according to the original gift; and consequently those who claimed under the original gift would not be barred because they obtained no recompense in value. It might happen in various ways that the estate which the tenant in tail had at the time of the recovery was not the estate tail according to the original gift. To prevent this inconvenience, the tenant in tail gave an estate of freehold to some person in order to make him a good tenant to the præcipe. This was done in various ways, but generally by bargain and sale enrolled, or by lease and release. The instrument which transferred the estate of freehold generally contained the declaration of the uses of the recovery, as hereinafter mentioned. The action being brought against the tenant to the præcipe, he vouched the tenant in tail, who vouched over the common vouchee. As the tenant in tail confessed the warranty, and undertook the defence of the action, he was considered to submit all his rights in the land to the effect of the recovery, which was called a recovery with double voucher.

A common recovery was generally suffered in the Court of Common Pleas; but common recoveries of lands in the counties palatine of Durham and Lancaster were suffered in the respective courts of those counties. A recovery of lands held in ancient demesne was suffered in the courts of the manors of which such lands were held; and in many manors a recovery might be suffered in the customary courts of such manors of which the copyholds were parcel.

The effect of a common recovery differed in several respects from that of a fine. A fine was originally introduced as a mode of alienation by record, and its effect in barring entails was owing to the statutes 4 Hen. VII., c. 24, and 37 Hen. VIII., c. 19, which were not made till several centuries after the introduction of fines. A common recovery had no absolute effect after a fixed number of years, as a fine had; but inasmuch as the recoveror acquired an estate in fee simple, it had effects very different from those of a fine. A common recovery duly suffered defeated all the remainders and reversions expectant on the estate tail, and also all shifting uses and executory devises expectant upon it, provided the recovery was suffered before the contingency happened on which the executory devise was to take effect. A fine had the effect of destroying the estate tail by converting it into a determinable fee. Accordingly if the tenant in tail who had the immediate remainder or reversion in fee barred his estate tail by a fine, he acquired a base fee, which was merged in the remainder or reversion, which thus became an estate in possession, and subject to all the charges and estates made and created by the person from whom the tenant in tail derived his remainder or reversion. Besides this, it would be necessary for such person on any occasion of selling his land, to make out his title, to the remainder or reversion. A common recovery operated by enlarging the estate tail into a fee, and thus absolutely destroying all remainders and reversions, but it confirmed all prior estates or charges made by the tenant in tail who suffered the recovery. Thus if a tenant in tail made a lease not permitted by the stat. 32 Henry VIII., or acknowledged a judgment, and then suffered a common recovery, this would be a confirmation of those charges, which, if there had been no recovery, would have had no effect against the issue in tail.

The origin of recoveries is referred to the decision in Taltarum's case 12 Edw. IV., in which, though it was declared that the estate tail in question was not barred by the recovery suffered, the reason that was given for the decision admitted that it might have been barred by a recovery. In Taltarum's case, the tenant who suffered the recovery was not seised of the estate tail under which the issue in tail claimed, but he was seised of a different estate at the time of the recovery being suffered.

Recoveries were impeachable for various reasons, such as defect of jurisdiction in the court in which they were suffered, informality in the proceedings, and the want of a good tenant to the precipe.

The immediate object of the recovery, as above observed, was to give an estate in fee simple to the recoveror; but the ultimate object was to commonly settle the estate to new uses, which were generally declared by the instrument which gave the estate of freehold to the tenant to the precipe.

By 3 & 4 Will. IV., c. 74, fines and recoveries were abolished, formal defects in those already levied or suffered were cured, and a simple mode of assurance substituted for the barring of an estate tail by deed enrolled in the court of chancery within six calendar months after its execution.

RECRUITING is the act of raising men for the military or naval service, either to augment the numerical strength of an army or fleet by new levies, or to make good the complement of any regiment or ship. The term may be used when men are obtained in any of the ways which the customs of nations have sanctioned, or the necessities of certain times may have required; but among military men it is employed when officers, especially appointed for the purpose, engage men by the offer of bounties to enter as private soldiers into particular regiments. The officers, commissioned and non-commissioned, while so employed, are said to be on the recruiting service; but the actual engaging of men as recruits is called enlistment; and the laws relating to this subject have been already noticed. [ENLISTMENT.]

Formerly private persons were allowed to enlist men for the army in any way that they might think best; but these having sometimes adopted, in order to procure recruits, violent and illegal means by which the public indignation was excited, the government in 1802 took the management of the recruiting department into its own hands; and now, by a clause in the Mutiny Act, any person advertising or opening an office for recruits without authority in writing from the adjutant-general is liable to the penalty of twenty pounds.

In order to produce uniformity in the system of recruiting, and to ensure the employment of legal means only in obtaining men, the supreme control of this branch of the military service was vested in the adjutant-general of the army, and both Great Britain and Ireland were divided into several recruiting districts. To each of these was appointed an inspecting field-officer; an adjutant, whose duty it is to ascertain, in respect of stature and bodily strength, the fitness of any recruit for the service; a paymaster, and a surgeon, the latter of whom is to report concerning the health of the recruit. Under the inspecting field-officer there are several regimental officers, who are stationed in the principal towns of the different districts in order to superintend the non-commissioned officers appointed to receive the applications of the persons who may be desirous of entering the service.

England and Scotland are divided into six recruiting districts, the head-quarters of which are respectively at York, Liverpool, Bristol, London, Glasgow, Edinburgh. Ireland is divided into three recruiting districts, of which the head-quarters are Belfast, Dublin, and Cork. Superintending officers are stationed at the various important towns in the district according to the exigencies of the service.

In order to procure recruits, a sergeant or other non-commissioned officer mixes, in country places, with the peasantry at their times of recreation; and, in towns, with artisans who happen to be unemployed, or who are dissatisfied with their condition; and, by address in representing whatever may seem agreeable in the life of a soldier, or by the allure of a bounty, occasionally induces such persons to enter the service.

The reports concerning the fitness of a recruit for military service are finally submitted for approval to the inspecting field-officer of the district, except when the distance of the head-quarters from the place where the recruit is enlisted is such that it would be more convenient to send the latter to the depôt of the regiment to which he is to belong: in that case the officer commanding at the depôt is especially authorised to sanction them.

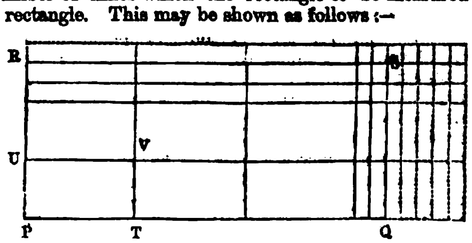
Officers employed on the recruiting service are not allowed to interfere with one another in the performance of their duties; particularly, no one is permitted to use any means in order to obtain for his own party a man who has already taken steps by which he may become engaged to another.

RECTANGLE (or right angled), the name given to any figure of which all the angles are right angles. Hence the figure having as many right angles as sides in the sum of its angles, must be foursided; for none but a foursided figure has the sum of its angles equal to four right angles. It is unnecessary to give a diagram of the most common of all the forms of art; the page of this book may serve as an instance.

The properties of the rectangle, to which it owes its importance in a mathematical point of view, consist of one which it shares in common with all parallelograms, and one which marks it as the most simple of parallelograms. Every parallelogram, and the rectangle among the rest, may be divided in an infinite number of ways into parallelograms having the same angles as the original parallelogram; and if any parallelogram be divided into others by lines drawn parallel to one only of the sides, the smaller parallelograms bear to the whole the same ratios which their several bases bear to the whole base. Also the area of a rectangle may be immediately deduced from nothing but the length of its two sides. If as a superficial unit we choose a rectangle having the sides A and B, it may immediately be told how many times and parts of times any other rectangle contains the unit. Measure one side, and see how many times it contains A (say $2\frac{2}{3}$); measure the other side, and see how many times it contains B (say $3\frac{2}{7}$); then the product of $2\frac{2}{3}$ and $3\frac{2}{7}$, or

$$\frac{8}{3} \times \frac{23}{7}, \text{ or } \frac{184}{21}, \text{ or } 8\,\frac{16}{21},$$

is the number of times which the rectangle to be measured contains the unit rectangle. This may be shown as follows:—



Let PQRS be the rectangle to be measured, and PTUV the unit rectangle, PU being A, and PT being B. The rectangle RQ is so drawn that PR contains $2\frac{2}{3}$ of A, and PQ contains $3\frac{2}{7}$ of B. The whole rectangle is obviously divided into six rectangles of the size of PV: six at the top, each of which is one-third of PV; four on the right, each of which is one-seventh of PV; and four higher up on the right, each of which is the twenty-first part of PV. We have then, on the whole, PV repeated

$$6 + \frac{6}{3} + \frac{4}{7} + \frac{4}{21}, \text{ or } \left(2 + \frac{2}{3}\right)\left(3 + \frac{2}{7}\right) \text{ times.}$$

In practice it is most convenient to make PT and PU equal to one another, and equal to the unit used in measuring lengths. Hence the rule for finding the area of a rectangle is: multiply together the number of linear units in the two sides, and the result is the number of square units (or squares on the linear unit) in the rectangle. This rule is abbreviated as follows: the product of the sides of a rectangle is the area; an abbreviation which often confuses the mind of a beginner, who imagines that two *lines* can be multiplied together [MULTIPLICATION], and that the rectangle, that is, the very shape of the rectangle, is the product; a mistake precisely that of a person who should imagine that the very silver of ten shillings could be multiplied by seven yards of stuff, and that the product could be seventy shillings. Now seven yards of stuff at ten shillings a yard certainly cost as many shillings as there are units in 7 × 10; and a rectangle whose sides are seven and ten feet certainly contains as many square feet as there are units in 7 × 10; but seven feet can no more be multiplied by ten feet than seven shillings by ten yards of silk.

When however given words imply a false proposition, there are two modes of proceeding, either to alter the words or to alter the meaning of the words. If a person should be so accustomed to talk of multiplying concrete quantities together that he cannot avoid it, he must learn to define multiplication as the finding of a fourth proportional to three concrete quantities, the first of which is a concrete unit. If this be the meaning of multiplication, then six yards and three yards can be multiplied together; for as one yard is to three yards so is six yards to eighteen yards, and eighteen yards is the product. But this product is a line, not an area.

The pertinacity with which some writers still persist in calling the product of two lines the area of a rectangle (not only as a practical rule of mensuration, in which it is a desirable mode of expression, but in matters of reasoning) is the result of a long-continued habit formed in the first instance by the study of the Greek writers. For though these do not confound the product with the area; yet, on account of the deficiencies of their arithmetical system, they used the area instead of the product, and gave the names of spaces to the results of numbers. Thus the product of two numbers was called plane, that of three equal numbers solid, that of two equal numbers a square, that of three equal numbers a cube, and the difference of two square numbers a gnomon. To these we may add the titles of polygonal, pyramidal, &c. numbers [NUMBERS, APPELLATIONS OF], and others which it is needless to mention. All arithmetical propositions were made to take the form of geometrical ones; thus to multiply two numbers was to form the rectangle of two given lines; to divide one number by another was, given the area of a rectangle and one of its sides, to find the other side. We have seen it stated that the word παραβολή (parabola) was sometimes used for quotient, and, it was said, in Diophantus. We cannot find it there, though it may be used by the scholiast, whom we have not examined. Adrianus Romanus, in his 'Apologia pro Archimede,' says that the Greeks use παραβολή for division as well as μερισμός. But most certainly the explanation of the meaning of a parabola, as applied to the well-known curve, comes from some such signification. The term parabola means a thing laid near to or by the side of another; for comparison, for instance, as in the common word *parable*, or for any other purpose. Now in the conic section in question the square on the ordinate being converted into a rectangle one of whose sides is the abscissa, the remaining side (being that which must be laid by the first side before the figure can be drawn, or the παραβολή) is always of the same length. If modern writers had applied the term parabola to this remaining side, they would probably have called the curve an isoparabolic section; but the Greeks, who called the curve in which a certain defect is always in the same proportion to the whole by the simple name of defect (ellipse), and one having the same sort of excess by the simple name of excess (hyperbola), called the isoparabolic curve simply a parabola.

Of the geometrical system which pervaded the Greek arithmetic, we have permanently retained only the words square and cube; rectangle was frequently used for product, but rarely at present. These words are the causes of much confusion to students who begin to apply arithmetic to geometry. Thus in algebra the square of a sum is equal to the sum of the squares of the two numbers, together with twice their product. In geometry the square or the sum of two lines is equal to the sum of the squares on the lines, together with twice their rectangle. Those who are not made to see clearly the distinction of these propositions confound them together. A sufficient distinction might be made by a little variation in phraseology: speak of the square *on* a line, and the square *of* a number. Thus 49 is the square of 7: erect two perpendiculars each equal to A B at the two extremities of A B, and joining their other extremities completes the square *on* A B. It is already customary to speak of the rectangle whose contiguous sides are A B and A C, as the rectangle *under* A B and A C.

The second book of Euclid is devoted to the properties of the rectangle, as they arise from subdivision into other rectangles. Some persons advocate what is called the arithmetical proof of these propositions, namely, the substitution of the analogous properties of numbers for those of rectangular spaces. This question must be settled in the same manner as that of PROPORTION, and the remarks in that article apply. If all pairs of lines were commensurable, no objection could be taken against the rigour of the substitution; but unless a theory of incommensurables, and a modification of the definition of multiplication to suit them, be formally introduced, the method of Euclid is sound, and the substitute for it unsound; though proper enough for the adoption of those who, as explained in the article cited, only wish to become mathematicians to a certain number of decimal places.

RECTIFICATION. [DISTILLATION.]

RECTIFICATION means the finding of a straight line equal in length to an arc of a curve [ARC], and is analogous to the term quadrature, as applied to finding its area; for in like manner as an area is considered to be known when a square equal to it is exhibited, so the length of an arc is known when a straight line equal to it is exhibited.

Of the celebrated problem of the rectification of the circle we have said enough under QUADRATURE OF THE CIRCLE, in which article it appears that the rectification gives the quadrature; so that the latter problem was generally attempted through the former.

RECTIFYING. [DISTILLING.]

RECTOR, RECTORY. [BENEFICE.]

RECURRING SERIES. By a recurring series is meant one of the form

$$a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4 + \dots$$

ad infinitum, in which the coefficients a_0, a_1, &c. can each be expressed by means of certain preceding coefficients and constants in one uniform manner; and it is usual to consider only such series as will admit of a linear relation (or one in which only first powers of coefficients enter): thus the series

$$1 + x + 4x^2 + 13x^3 + 43x^4 + 142x^5 + \dots$$

follows the linear law $a_n = 3a_{n-1} + a_{n-2}$ ($4 = 3 . 1 + 1$, $13 = 3 . 4 + 1$, $43 = 3 . 13 + 4$, &c.), and is what is commonly called a recurring series, though the following—

$$1 + x + 2x^2 + 5x^3 + 29x^4 + 866x^5 + \&c.,$$

in which $a_n = a_{n-1}^2 + a_{n-2}^2$, is equally recurring, according to the definition. The recurrence alluded to is not that of terms, but of method of determining terms; and it would be desirable that the series which are usually called recurring should be *linearly* recurring series, while all in which there is really recurrence (of law) should be called recurring.

Every linearly recurring series is the development of an algebraic function with a rational and integral numerator and denominator, and every such function can be developed into a linearly recurring series. Thus, taking the first series mentioned, in which $a_n = 3a_{n-1} + a_{n-2}$, we have

$$\begin{aligned} a_2 x^2 &= 3a_1 x^2 + a_0 x^2 \\ a_3 x^3 &= 3a_2 x^3 + a_1 x^3 \\ a_4 x^4 &= 3a_3 x^4 + a_2 x^4, \text{ \&c.} \end{aligned}$$

Let s be the sum of $a_0 + a_1 x +$, &c., *ad infinitum*. Then the preceding obviously gives

$$s - a_0 - a_1 x = 3x (s - a_0) + x^2 s;$$

$$\text{or, } s = \frac{a_0 + (a_1 - 3a_0) x}{1 - 3x - x^2}$$

We have here the value of any series in which this law of recurrence prevails for all terms after the second; and it cannot prevail before, since two terms must exist before a third can be expressed. In the case we chose, $a_0 = 1$, $a_1 = 1$, whence the function of which the series was the development is $(1 - 2x) \div (1 - 3x + x^2)$.

Generally, a linear recurring series having the law of recurrence

$$a_n = p_1 a_{n-1} + p_2 a_{n-2} + \dots + p_t a_{n-t}$$

is the development of the function

$$\frac{A_0 + A_1 x + A_2 x^2 + \dots + A_{t-1} x^{t-1}}{1 - p_1 x - p_2 x^2 - \dots - p_t x^t}$$

where $A_0 = a_0$, $A_1 = a_1 - p_1 a_0$, $A_2 = a_2 - p_1 a_1 - p_2 a_0$, ...

$$A_{t-1} = a_{t-1} - p_1 a_{t-2} - p_2 a_{t-3} - \dots p_{t-1} a_0,$$

from which the inverse theorem may easily be derived, namely, that

$$\frac{A_0 + A_1 x + A_2 x^2 + \dots + A_{t-1} x^{t-1}}{B_0 + B_1 x + B_2 x^2 + \dots + B_{t-1} x^{t-1} + B x^t}$$

can be developed into $a_0 + a_1 x + a_2 x^2 + \&c.$, in which the law of recurrence (n not being $< t$) is as follows:—

$$B_0 a_n + B_1 a_{n-1} + B_2 a_{n-2} + \dots + B a_{n-t} = 0,$$

and the terms up to a_{t-1} are determined by

$$A_0 = B_0 a_0, A_1 = B_0 a_1 + B_1 a_0, A_2 = B_0 a_2 + B_1 a_1 + B_2 a_0 \dots$$

$$A_{t-1} = B_0 a_{t-1} + B_1 a_{t-2} + \dots + B_{t-1} a_0.$$

Those who understand the theory of generating functions will see that the generating function can thus be found to the solution of any linear equation of differences. Some use may thus be made of recurring series in various questions of the theory of probabilities; but, generally speaking, this species of series is not of the most useful kind, connected as it is with the rational and integral function of algebra, which is of little application compared with the irrational and transcendental function. [SERIES.]

The most simple mode of finding the law of the terms of a recurring series is by the solution of the equation of differences, which expresses the relation of the coefficients. This may be verified by decomposing the function which is developed into the series into fractions with denominators of the first degree, according to the common method used in the integral calculus, and expanding each fraction separately.

RECUSANTS are persons who refuse or neglect to attend divine service on Sundays and holidays, according to the forms of the Established Church. Before the Reformation, ecclesiastical censures were directed at different times by provincial councils against those who absented themselves from the services of the church. But the noticing of recusancy in the temporal courts, and probably the use of the term itself, cannot be traced higher than the 16th century. By the 1 Eliz., c. 2, all persons having no lawful excuse are to resort to their parish church upon pain of punishment by the censures of the church, and a forfeiture of twelve pence. By 23 Eliz., c. 1, every person above the age of sixteen years who shall not repair to church, forfeits for every month which he forbears, twenty pounds, and by 35 Eliz., c. 1, if recusants within three months after conviction refuse to submit, they may be compelled to abjure the realm; and if they do not depart, or if they return without licence from the crown, they are guilty of felony, and liable to suffer death.

The law recognised four classes of offenders under the statutes against recusancy:—those who absented themselves from the public service of the church from indifference, irreligion, or dissent, were termed "recusants" simply — after conviction they were styled "recusants convict"; those absentees who professed the Roman Catholic religion were called "Popish recusants"; and those who had been convicted in a court of law of being Popish recusants were called "Popish recusants convict."

The laws against Popish recusants convict were of a very severe character. Blackstone says that these laws were enacted principally *in terrorem*. The truth appears to be that the first penal statutes passed for the purpose of compelling the adherents of the old religion to adopt the new, provoked resistance on their part; and this resistance caused severer enactments, producing in their turn increased resistance, followed by the imposition of still more rigorous penalties.

Popish recusants, in addition to the general penalties enacted against recusants, were disabled from taking lands, either by descent or by purchase, after eighteen years of age, until they renounced their errors. They were bound at the age of twenty-one to register the estates which they had already acquired, and were bound also to register all future conveyances and wills relating to them. They were and are [QUARE IMPEDIT] incapable of presenting to any living, or of making a grant of the right of presenting at any avoidance of the benefice. They could not keep or teach any school, on pain of perpetual imprisonment, and for the offence of saying or hearing mass, forfeited certain sums, and were in each case subjected to a year's imprisonment.

Popish recusants convict incurred additional disabilities, penalties, and forfeitures. They were considered as persons excommunicated: could not hold any public office; were not allowed to keep arms; were prohibited from coming within ten miles of London; could bring no action at law or suit in equity; and were not permitted to come to court, or to travel above five miles from home except by licence, upon pain of forfeiting all their goods. Penalties were also imposed in respect of the marriage or burial of the Popish recusant convict, or the baptism of his child, if the ceremony were performed by any other than by a minister of the Church of England. Such a recusant, if a married woman, forfeited two-thirds of her dower or jointure, was disabled from being executrix or administratrix of her husband, and from having any part of his goods, and she might be kept in prison, unless her husband redeemed her at the rate of 10*l.* per month, or by the profits of the third part of all his lands.

Protestant dissenters were relieved from the penalties of recusancy at the Revolution, by the Toleration Act, 1 William & Mary, c. 18. This statute contained a proviso depriving of its benefit any Papist or Popish recusant, or any person that should deny the doctrine of the Trinity. But in 1791, by 31 Geo. III., c. 32, Roman Catholics were exempted from prosecution; and in 1813, by 53 George III., c. 160, the exemption in the Toleration Act, as to persons denying the doctrine of the Trinity, was repealed. The statutes against recusancy, though never enforced, still subsist with respect to persons who, not being Roman Catholics or Protestant dissenters, absent themselves from the service of the Church.

RED. [CALICO PRINTING; DYEING; ENAMEL; PAINTING, HOUSE.]

RED LEAD. [LEAD: *Red lead.*]

RED OCHRE. [COLOURING MATTERS.]

REDAN is the simplest kind of work employed in field fortification, and it consists generally of a parapet of earth, divided on the plan into two faces, which make with one another a salient angle, or one whose vertex is towards the enemy. Existing alone, the work is capable of making but a feeble defence, since its faces are not defended by any flanking fire; and, being open at the gorge or rear, the enemy may easily enter it in that direction. It can therefore be of use only at an outpost, to afford a momentary cover for troops who are to retire when a superior force advances against them. A redan may however be advantageously placed to cover the head of a bridge, the entrance into a village, or defend the ground in front of some strong redout; a series of them may also be constructed along the front of an army, in order to strengthen the position and cover the artillery; and, in all these situations, the defects above mentioned cease to exist, since in the first case the gorge is protected by the river, and in the others the faces and gorges are defended by the works or by the troops in the rear.

When it is required to defend any pass immediately on the right or left of redans, flanks, making salient angles with the faces at points near the extremities of the latter, are given to them, so that they then become what are also called bastions or lunettes; and the necessity of having a crossing fire for the defence of the ground in front, when the redans are not flanked by other works, has at times induced engineers to break the lines of parapet near the gorges, so as to form re-entering bends, and thus constitute a wing on each side at a right angle with the face.

Among the works constructed, in 1810, for the defence of Lisbon, redans were frequently placed on projecting knolls, in front of the great redouts, in order to flank the ground which was unseen from the latter: their gorges were protected by palisades, or by parapets, sufficiently slender to have been demolished by the artillery of the principal work, had the enemy succeeded in capturing them; and good communications, covered by the inequalities of the ground, or by earth purposely thrown up, were formed in order to allow the defenders, if necessary, to retire in security. The strong stone windmills, which in that country are often built on salient knolls of ground, were occasionally covered by redans of earth; and thus were formed good defensive posts, to each of which the mill served as a reduit or keep. During the struggle in the south of France, in 1813, Marshal Soult caused redans to be constructed as outworks, one below another, on the descending tongues of land which project from the main chains of heights whose summits he had crowned by strong redouts.

Two redans connected together, so as to leave one re-entering angle in front, form a queue d'hyronde; and the name of bonnet de prêtre has been sometimes applied to a work consisting of three redans so placed.

REDEMPTION. [ATONEMENT.]

REDEMPTION, EQUITY OF. [MORTGAGE.]

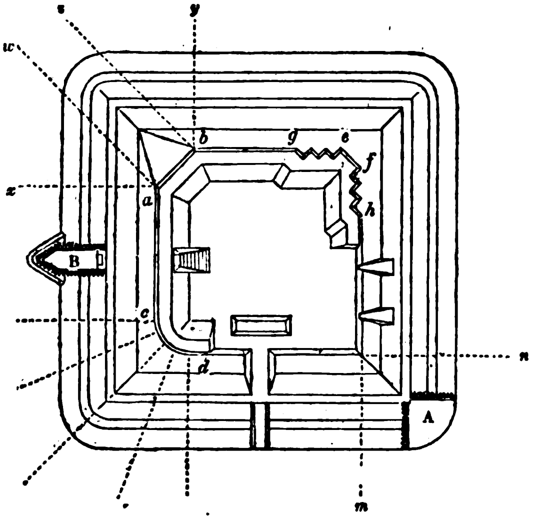
REDOUT is a general name for nearly every kind of work in the class of field fortifications; thus, a redan with flanks, a parapet enclosing a square or polygonal area, a work in the form of a star [STAR-FORT], and a fort with bastions at the angles, like the enciente of a fortress, are occasionally so called; but the second of these is the work to which the term is more particularly applied, and it is that which we propose now to describe.

When a work to be constructed on level ground is intended to contain troops and artillery for the purpose of preventing the enemy from occupying the spot, and when there is an equal probability that the work may be attacked on any side, that spot should be quite enclosed by the parapet; also if the defence is to continue only till succour can arrive from the army in the vicinity, flanking defences being then scarcely necessary, a quadrangular figure may suffice for the plan of the work, and there can be no reason why one side should be longer than another, or why the sides should form with each other any but right angles. But when the redout is to occupy an eminence whose figure on the plan is irregular, the faces of the work, whatever be the form thus produced, must necessarily be traced so as to correspond to the different directions assumed by the brow of the height; and if the fire of the work is intended to defend some fixed object, as a pass leading towards it, one of the faces must be perpendicular to the direction of that pass. It may be observed, however, that in general the number of faces, though not less than four, should be as few as possible. The ditches of all polygonal works without re-entering angles, are incapable of being defended by the fire from the parapets above, on account of the height and thickness of the latter, which prevent the soldiers from seeing them; and a curvilinear redout has, besides, two defects which are irremediable: the fires from its parapets are diverging, therefore they produce little effect while the enemy is advancing up to the work; and the ditch, on account of its form, is incapable of being defended from stockades within it. These objections apply with nearly equal force to redouts formed on regular polygons of more than five or six sides. The French, however, made a circular redout of casks for the purpose of strengthening the defence of the isthmus at St. Sebastian, previously to the siege of that place in 1813; and circular redouts of masonry are supposed to be useful on the sea-coasts. In the latter situation they are not liable to be attacked by infantry; and their artillery, which is mounted on traversing platforms, may be fired in any direction against ships or boats, should an enemy attempt a debarkation of troops. [MARTELLO TOWERS.]

Every work in field as well as in permanent fortification is surrounded by a ditch, from whence is obtained the earth for the parapet, and by which the difficulty of carrying it by assault is increased. The ditch is generally crossed directly opposite the entrance by a bridge of timber, which should be capable of being drawn into the work, or replaced at pleasure. The entrance into a redout is at a re-entering angle, if there is one, otherwise it may be about the middle of one of the faces on the side which is least exposed to the view of the enemy; and, besides being barricaded, it is defended by the fire from a traverse, which is raised in the interior, and perpendicular to the direction of the passage.

Redouts for the defence of positions are in general intended to contain only about fifty men with three guns; but works in the form of irregular polygons have sometimes been constructed of a magnitude sufficient to contain 1600 men and twenty-five pieces of artillery; and such were the two principal redouts (on Mount Agraça and at Torres Vedras) formed in 1810, in order to protect Lisbon. These were expected to make a vigorous defence in the event of being attacked; but it is admitted that their *trace*, or ground-plan, was defective on account of the want of flanks, and perhaps they would have been prevented from falling only by the strong divisions of troops who were daily under arms in their vicinity. The redout constructed by the British in the neighbourhood of Toulon, in 1793, for the protection of the town and fleet, was a large work well furnished with artillery; yet, on being attacked by the republican troops, it was taken, after a gallant resistance, in which the enemy was twice repulsed. The ditches being undefended by flanks, the assailants, on being driven into them, re-formed their order with little molestation; and at the third attack they succeeded in getting possession of the work.

It is admitted among military men that in firing over a parapet, the soldier doing the duty as rapidly as possible, and fearing to expose himself while adjusting his musket, places the latter mechanically in a direction nearly perpendicular to the line of the face behind which he is stationed. It follows that in front of every salient angle of the work there must be an undefended sectoral space, as *m n* in the subjoined cut, which represents the plan of a square redout, in which space, in order to avoid the direct fire from the faces, the enemy may advance to the attack; and on this account it is recommended that the faces of the work should be disposed so that the angles may be turned towards ground which is impassable, or which will not permit the enemy to establish batteries for the purpose of enfilading those faces. When this disposition is not possible, various methods may be adopted by which the troops who man the work might direct some of their fire within those sectors. The simplest of these, and that which is generally put in practice, is to form the crest of the parapet near the angle, perpendicularly to the *capital* (the line bisecting the angle) as at *a b*; by which means the space between *w* and *z* may be directly defended, and the sectors *x w* and *z y* being small, very little attention on the part of the men about *a* and *b* will enable them to give their muskets an oblique direction so as to fire upon an enemy advancing within those spaces. A second method is that of rounding off the interior of the parapet at the angles, as at *c d*; but this has been objected to on account of the divergency of the lines of fire. The third method, which is much dwelt on by writers on fortification, consists in forming the interior of the parapet with indentations, as at *eg* and *fh*, alternately parallel and perpendicular to the capital, each indent being three feet long; and a parapet of this kind is said to be *en cremaillère*. It is evident that by placing men contiguously to the sides of these indentations, a fire may be kept up in either of the directions just mentioned; and by placing them at the angles, they may fire perpendicularly to the general face of the work. It must be observed, however, that the men cannot fire in these different directions at the same time, because, the muskets crossing one another, that of one man might be injured by the fire of the next, and therefore what is gained in one direction is lost in another. The only objections to this method are, that the parapet can be so formed only by men belonging to the corps of Royal Engineers, who are regularly trained to the construction of fortifications, but who may not be present when wanted; and that the unsteadiness of the soldiers in firing almost always renders such precision in the formation of the work useless.



The ditch of a redout having no flanks, being unseen and incapable of defence from the parapets, it has been proposed, in order to have some means of annoying the enemy when in the ditch, to form an enclosed space A, at one or more of the angles of the ditch, by planting a line of palisades across the latter on two contiguous faces of the work; the enclosure may have a roof of timber covered with earth, and loop-holes, three feet asunder, must be cut in the palisades, that the defenders may be enabled to fire along the ditches.

Another method, which may be advantageously adopted when a face of the work has considerable length, is to form, as at B, what is called a palisade caponnière, by planting across the ditch, at the middle of the face, two rows of palisades about eight feet asunder; each row being pierced with loop-holes. The entrance into the caponnière is by steps in the interior of the redout and a gallery under its parapet; and this work, as well as that at A, may have a roof, but in no case should such roof be above the level of the natural ground, in order that it may be concealed as long as possible from the view of the enemy. And if practicable, the floor of the caponnière may be sunk, so that the roof being only a few feet above the level of the ditch should not afford a bridge by which to enter the work. One of the redouts which was executed near Lisbon, being commanded by a height in its front, from whence the parapets might have been destroyed and the interior ploughed by shot, there was formed a gallery behind the counterscarp, and opposite one of the angles of the work, with loop-holes, from whence the ditch along each face might have been defended by musketry if the enemy had penetrated into it. The soil being chalk, no timber-frames were necessary for the support of the sides or top; and between this recess and the interior of the redout there was a gallery of communication passing under the bottom of the ditch.

A row of palisades is frequently planted quite along the ditch of a redout. Sometimes also the escarp of the work is fraized, or furnished with palisades planted in an inclined position, and a line of chevaux-de-frize is disposed upon the bermé. In order to retard the advance of an enemy, the work is generally surrounded, at a distance not exceeding the range of musket-shot, by a single or double abatis, and often by two rows of pits called *trous de loup*.

The magnitude of a redout, whatever be its form, is determined by the strength of the garrison and the quantity of ordnance by which it is to be defended; all the men being supposed to be lodged within it. It was formerly the practice to allow on the area of the *terreplein*, within the foot of the banquette, ten square feet for each man, and 324 square feet for each piece of artillery; consequently when the redout is of a square form, the breadth of the banquette being known (about 11 feet), the length of the crest-line on each face could be easily determined. In order that the defenders may conveniently use their arms on the banquette, it has been customary to allow three feet along the crest of the parapet for each man, who is to stand contiguously to the interior slope; and it was once considered that a redout intended to make a considerable resistance when attacked on all sides, would be adequately garrisoned if the number of men in it were equal to the number of feet in the whole length of the crest of parapet; that is to say, if there were three ranks of men along each face, the work being supposed to be capable of containing such a number. It is said that each side of the square redouts which Marshal Saxe caused to be constructed at the siege of Maestricht, in 1748, was above 100 feet long, measured on the crest of the parapet, and that each redout was garrisoned by 500 men; and it will be found by computation that, consistently with the above rules, a square redout, each of whose faces is sixteen yards long, is the least that ought to be constructed; for if less, the interior within the banquette would not contain the number of men necessary to line its parapet with one rank. But the rule relating to the area within the banquette has been objected to as an unnecessary affectation of mathematical precision. The British engineers who constructed the works for the protection of Lisbon observe that, except at night, or at the moment of being attacked, part of the garrison will be on watch, or otherwise occupied outside of the work; and even at those times at least one-third will be under arms on the banquette. Colonel Sir John Jones states that the strengths of the garrison were finally determined by allowing two men per yard in the length of the parapet for the exterior works, and one man per yard for the interior works; deductions being made for the spaces where artillery was to stand. Each gun takes up about eighteen feet of the length of a parapet.

The crest of the parapet of a redout may be about 8 feet above the natural ground, unless the work is to be defiladed from some commanding ground in the neighbourhood, in which case it must be higher. The form of a section or profile of the parapet is similar to that which is used for permanent fortification [Lines of Intrenchment, *Fig.* 4], but the breadth of the superior slope may vary with the nature of the arm which the enemy can bring against it; three feet will suffice if the work can be attacked by infantry only, but it may be as much as 10 or 12 feet if it is to resist field artillery of the heaviest calibre. The superior surface of the parapet should slope down towards the exterior, so that the defenders may see the top of the counterscarp of the ditch in front; and when, from the great relief of the work, this is impossible, the counterscarp should be raised by earth obtained from the ditch to the height necessary for this purpose; taking care, however, to give the raised earth a gentle slope towards the exterior, that the enemy may not be screened by it. The exterior of the parapet and the escarp of the ditch are covered or revetted with sods when the earth has not sufficient tenacity to stand unsupported; and when the work is to resist the fire of heavy artillery, the revetment might consist of stout logs of timber planted obliquely in the ground or in the bottom of the ditch, and leaning against the face of the work. The interior of the parapet is usually revetted with sods or fascines.

Redouts are intended to fortify military positions, for which purpose they usually occupy the heights and command the defiles; and their magnitude or number must depend upon the time afforded for their construction. [Lines of Intrenchment; Military Positions.] It sometimes happens that they are thrown up during the night to protect artillery on the wings, or in some important situation in front of the army, in expectation of an engagement taking place the next day; and then they are necessarily few and small. When

Marshal Soult was reduced to defensive operations in the south of France, in 1813 and 1814, he strongly entrenched the heights on all the frontier between the sea about Bayonne and St. Jean-de-Luz, and the mountains at St. Jean-Pied-de-Port; an extent of above sixteen miles. The works, which were executed in three months, were generally irregular polygons; and some of them were constructed for 500 men. More than a year was spent in raising the redouts which covered Lisbon; and consequently these were not only strong, but numerous beyond any other example. [ENCAMPMENT.] They were of every trace, but mostly irregular polygons, whose sides sometimes formed re-entering angles, as the ground required: the two great redouts before mentioned were retrenched by interior parapets, which also served as traverses, and each salient point of the redout at Torres Vedras constituted an independent post.

Attack and Defence of a Redout.—In the attack of a small redout unprovided with artillery, light infantry, or riflemen, keeping for a time as much as possible covered by the inequalities of the ground, endeavour to surround the work, and, by a fire of musketry, directed towards the crest of the parapet, to diminish that of the defenders. The assailing troops then gradually close in upon the redout, and, while one division remains on the counterscarp to continue the fire, should the defenders show themselves upon the parapets, the rest descend into the ditch, where, having collected themselves in parties or small columns, they mount the parapet on each side of a salient angle; then developing themselves on the summit, they make a general discharge and enter the work. In order to avoid accidents in descending into the ditch, or in ascending the escarp, it is recommended that the bayonets should not be fixed by the assailants till they have gained the berme of the work.

But if the redout is of considerable magnitude, if it is furnished with artillery, and moreover protected by palisades in the ditches, and abatis or other obstacles in the front, the attack must be conducted with more powerful means. It should commence by a fire of artillery directed partly so as to enfilade the parapets, break down the palisades and derange the abatis, and partly to destroy the merlons which cover the artillery of the work. The fire of the latter being thus in some measure silenced, the light infantry, as in the former case, endeavour by musketry to prevent the defenders from manning the parapets; and in the mean time columns of troops advance towards the angles, being preceded by parties of sappers and miners, who make openings for them in the line of abatis, or cover with timbers the trous de loup, if such there be. If the ditch is deep, the descent into it, and the subsequent ascent of the escarp, must be facilitated either by placing scaling-ladders or by throwing in fascines or bags of hay; and any palisades or other obstacles which may not have been displaced by the artillery, must now be cleared away by the working parties which accompany the troops. The fire of the covering parties must cease while the assailants are mounting the parapet, but it must recommence if they should be repelled: in the latter case the storming troops reform their order in the ditch, and again attempt to enter the work. It may be supposed that at length they will succeed, when the defenders, if not provided with a redout, to which they may retire for the purpose of capitulating, must surrender at discretion. In 1793, the French camp under Valenciennes was protected by works which, though furnished with artillery, were open at the gorge; and in an attack, the British cavalry, having entered those works at their rear, made prisoners of all the defenders.

When a redout is threatened with an attack, the officer commanding it endeavours to provide against the event by disposing in front of the work all possible obstacles to the advance of the enemy, and by placing sand-bags on the parapets in order to cover the defenders, who are to fire through small intervals left for the purpose: these measures should be taken, if not before, during the night preceding the attack; since the latter generally takes place early in the morning. On the advance of the assailants, the artillery of the work is made to play upon their columns; and the fire of musketry commences as soon as the latter are within the proper range. These fires are kept up vigorously while the assailants are clearing away the obstacles, and until they have descended into the ditch. Should the work have flanks, and the guns behind them be not dismounted, a fire of grape-shot and of musketry must now be directed along the ditches; while hand-grenades and stones are thrown, and live shells are rolled into them from the parapets of the faces. The storming troops may however persevere, and may at length mount upon the parapet, in which case they must be received by a fire of musketry from the defenders on the terreplein; and the latter, if overpowered, must endeavour to retire or capitulate.

Any works constructed within others, in order to prolong their defence, or to afford a retreat for the troops who occupy them, are also called redouts; but by the French engineers, reduits or retrenchments. [RETRENCHMENT; BLOCK-HOUSE.]

REDUCTIO AD ABSURDUM. [ABSURDUM, REDUCTIO AD.]

REDUCTION. This term is used in arithmetic in the well-known sense of the operation of turning one denomination of weights or measures into another: thus shillings may be reduced to pounds, or pounds to shillings. It is also used in the same sense throughout analysis, namely, that of bringing one form into another, making one question depend upon another, &c.; in fact, for transformation generally. It were to be wished that the latter word transformation should take its place whenever the two forms are of equal difficulty or the two questions of the same character, &c., and that reduction should be employed only when there is really a reduction; that is, a bringing down either of dimension or difficulty, &c. Many writers do use the word thus, and thus only, but others do not.

REDUCTION INTO POSSESSION. [POSSESSION.]

REEFS, or CORAL REEFS, are a peculiar kind of rock which occurs abundantly in some parts of the ocean. They differ from other rocks in extending over a considerable space of the sea in length, with a very narrow width. Generally they are also only a few feet below water; so that on the side where they are washed by the open sea, a heavy surf is continually running against them.

Reefs appear under various forms. In some places they are contiguous to the shores, as in the Red Sea; in others they fringe the shores, being separated from them by a narrow channel of moderate depth. Sometimes they surround islands at a considerable distance from the shores, and the islands so encircled are almost without exception of volcanic origin. Very frequently they surround a portion of the sea, within which there are some small islands, which are often contiguous to the reefs, and seem to be a part of them, as both are composed of the same material. There are also coral reefs at a great distance from the land, which run nearly parallel to it, like a barrier. Among the latter are those of the Coral Sea, along the eastern coast of Australia.

The attention of navigators and naturalists was first attracted to those islands which go under the name of Lagoon Islands. A reef approaching in form to a circle surrounds a part of the sea and forms a lagoon, on the inner part of which there are usually several smaller islands, wooded and inhabited, which are contiguous to the reefs themselves, and frequently extend along them with little interruption. The water on the outside is always nearly unfathomable, but within the reefs good anchorage is generally found, and the reefs themselves have one or more openings of deep water by which the largest vessels may enter the lagoon. Accurate observers soon discovered that the reefs were composed of coral, and were the production of an animal. On these circumstances the first theory of reefs was founded. This theory received some addition from Forster, who accompanied Captain Cook on his second voyage. According to him, they are raised by these small animals perpendicularly like a wall, from a great depth to a very small distance from the surface of the sea. The waves afterwards bring sand, muscles, tang, and pieces of coral, and deposit them on the reef, which, in this way, is gradually raised above the sea-level, and becomes fit for vegetation. Currents and sea-fowls bring the seeds of marine plants, which, being decomposed, form a mould on which the cocoa-nut palm, when carried thither by the waves, thrives luxuriantly. This theory of Forster was adopted and extended by Flinders, who in surveying the coasts of Australia had abundant opportunities of observing the formation of these islands; and still more by Peron and Chamisso. The last-mentioned naturalist accompanied Kotzebue on his first voyage of discovery (1815-1818).

But facts have since been observed by Quoy and Gaimard, who accompanied Freycinet on his voyage, and published their observations in the 'Annales des Sciences Naturelles,' which are inconsistent with this theory. They found that the reefs did not entirely consist of coral, and that the layer of coral hardly exceeded a few fathoms in depth. Besides this the polypiaria which are able to form such a layer do not inhabit the sea to any great depth, and are not found where the water is more than 30 feet deep. They therefore supposed that these animals executed their work only in those parts of the sea where the bottom had been raised by some natural cause nearly to the surface of the water. They supported their theory by adducing the fact that the continuity of every lagoon-reef was broken at one or more places, so as to constitute a strait of very deep water, which could not be the case if these works were carried on at a depth of from 100 to 200 fathoms. This theory coincides with the views adopted by Von Buch, in his description of the Canary Islands, and has been adopted by Ehrenberg, in his pamphlet 'Ueber die Natur und Bildung der Coralleninseln und Corallenbänke im rothen Meere;' and by Darwin, in the third volume of the 'Surveying Voyages of the Adventure and Beagle.' The last-mentioned writer however does not doubt that the reefs which form the lagoon islands are composed of coral to a great depth, much greater indeed than those polypiaria which form them can live in. He explains this in a very ingenious way, by supposing that they formerly had an elevated island in the middle, but that in those portions of the sea where they now occur, the bottom of the waters was gradually lowered by subsidence, by which the polypiaria were enabled to continue their work farther, and the mountainous islands in the middle disappeared. In other parts of the Pacific and Indian oceans the contrary is supposed to have taken place: the bottom of the sea was elevated, and in these tracts volcanic islands occur. He observes that in this respect these seas may be divided into broad bands, in which an elevation and submersion has alternately taken place; and he draws from it some important inferences (p. 562-569).

Mr. Darwin has subsequently produced a work, entitled 'The Structure and Distribution of Coral-Reefs, being the first part of the Geology of the Voyage of the Beagle,' London, 1842, 8vo, pp. 214, in which he has stated his views in a systematic and comprehensive manner. He observes that, without any distinct intention to classify coral-reefs, most voyagers have spoken of them under the following heads, which are nearly identical with the descriptive terms already employed in this article:—Lagoon Islands, or Atolls; Barrier, or Encircling Reefs; and Fringing, or Shore Reefs. With respect to the lagoon islands, he remarks, everyone must be struck with astonishment when he first beholds one of these vast rings of coral-rock, often many leagues in diameter, here and there surmounted by a low verdant island with dazzling white shores, bathed on the outside by the foaming breakers of the ocean, and on the inside surrounding a calm expanse of water, which, from reflection, is of a bright but pale green colour. The naturalist, he adds, will feel this astonishment more deeply after having examined the soft and almost gelatinous bodies of the apparently insignificant creatures, the polypifers [Polypifera, in Nat. Hist. Div.], which construct these vast works; and when he knows that the solid reef increases only on the outer edge, which day and night is lashed by the breakers of an ocean never at rest. As the reef of a lagoon island generally supports many separate small islands, the word "island," applied to the whole, is often the cause of confusion; on which account Mr. Darwin in this work invariably uses the term "atoll," which is the name given to these circular groups of coral islets by their inhabitants in the Indian Ocean, and is synonymous with lagoon island. Reefs in most respects allied to those of the fringing class also occur around submerged banks of sediment and of worn-down rock; and others are scattered quite irregularly where the sea is very shallow. Mr. Darwin has given a separate chapter of his work to each of these classes of coral-reefs; but the classification, he states, admits of a more fundamental division into atoll-formed and barrier-reefs on the one hand, where there is a great apparent difficulty with respect to the foundation on which they must first have grown; and into fringing-reefs on the other, where, owing to the nature of the slope of the adjoining land, there is no such difficulty. Barrier-reefs, though little less marvellous in their structure than atolls, had previous to Mr. Darwin's researches received but little attention, and scarcely any attempt had been made to explain their origin. He concludes, in conformity with the summary statement of his theory, given above, that in them as well as in atolls, the foundation on which the coral was primarily attached has subsided, and that during this downward movement the reefs have grown upwards. "This conclusion," he says, "explains most satisfactorily the outline and general form of atolls and barrier-reefs, and likewise certain peculiarities in their structure. The distribution, also, of the different kinds of coral-reefs, and their position with relation to the areas of recent elevation, and to the points subject to volcanic eruptions, fully accord with this theory of their origin." After three descriptive chapters, Mr. Darwin describes in three others the distribution and growth of coral-reefs, gives in detail his theory of the formation of the different classes, and discusses their distribution with reference to the theory of their formation. In an appendix, every existing coral-reef is briefly described in geographical order, as far as the author possessed information; and their distribution over the equatorial regions of the globe is further illustrated by a map.

Still more recently, since the year 1847, the subject of coral-formations has been treated at great length by Dr. James D. Dana, in the 'Geology' of the 'United States Exploring Expedition,' during the years from 1838 to 1842, under Commander Wilkes, U.S.N. This volume was published at New York, but is undated.

REFINING. [Assaying; Copper; Lead; Sugar.]

REFLECTING TELESCOPES. [Telescope.]

REFLEXION AND REFRACTION. [Light; Optics; Refraction, Refrangibility.]

REFORMATION is the name generally given to the great schism which took place in the Western Church in the first half of the 16th century, and by which a large part of the population of Europe has become separated from the Church of Rome; besides which, the great majority of the people of the United States of North America, as well as of the English and Dutch colonies, follow the same mode of faith.

In order to understand correctly the history of the Reformation, it is necessary to be acquainted with the social, political, and intellectual state of Europe in the 15th century; and for this purpose the histories of the councils of Constance and of Basel, and the 'Historia Bohemica,' by Æneas Sylvius Piccolomini, are of great service. [Pius II., in Biog. Div.] Previous to the Reformation the see of Rome claimed of divine right, and asserted, with the assistance of the lay power of the various states of Europe, an absolute authority over the whole Christian Church; indeed, a universal authority, as exemplified by the gifts of the Western world, the inhabitants being heathens, to the monarchs of Spain and Portugal; while the Greek Church was denounced as heretical. By virtue of this supreme authority, the Roman pontiff decided absolutely all doubts and disputes which might arise, whether in matters of doctrine, jurisdiction, or discipline: his decisions were considered as infallible; and whoever resisted or gainsayed them was considered a heretic, and as such liable to canonical censures, and also to the temporal penalties awarded by the canon law against heretics. The government of the Church was therefore absolute; and the Church, or rather the bishop of Rome, as head of the Church, assumed also a supremacy even in temporal matters, although the exercise of this last supremacy was resisted by various princes. [Gregory VII.; Innocent III.; Innocent IV.; Gregory IX., in Biog. Div.]

The great object of the Reformers of the 16th century was to overthrow the principle of absolutism in the government of the Church, by contesting the infallibility and supremacy of the bishop of Rome. This had been already contested, and indeed set aside by the councils of Constance and of Basel; but the point of contention had never been finally and permanently settled. The Reformers of the 16th century, however, went much farther: they denied the absolute authority even of the councils, and they leaned towards the popular or democratic principle in religious matters, by allowing the right of individual interpretation of the Scriptures, and discarding all tradition and human authority in matters of faith; and as in the course of their struggle they were met by several dogmas or doctrinal tenets derived either from passages of the Scriptures as interpreted by the Roman Church, or from tradition, or from decisions of the councils or decretals of the popes, which were urged in opposition to them, they set about translating and commenting on the Scriptures, substituting a different interpretation of the disputed passages, and thus sapping the very foundations of the whole fabric of Church authority.

It has been maintained by several writers that the principles asserted by Luther and other reformers were those of the early ages of the Church; but all that can be proved seems to be that in almost every age since the apostolic times there has been here and there a display of opposition to the absolute system in the Church; that some peculiar doctrines of Luther and Calvin had been asserted by others long before them; and that the Valdenses especially, and their neighbours of the valleys of Dauphiné, had retained from time immemorial a system of Church discipline similar to that established by the Reformation in the churches of Switzerland and Scotland.

The progress of the Reformation in Germany and Switzerland has been related in the Biog. Div. under the names of the chief actors in that great movement. [Luther; Bucer; Melancthon; Zwingli; Calvin; Charles V.; Ferdinand I.; Maurice, Duke of Saxony; and others.]

The Reformation in England sprung from among the people and the clergy. It had begun with Wycliffe; it spread from England to Germany among the Lollards and the Hussites, and was carried back from the Continent to the shores of Britain with a fresh impulse from the preaching of Luther, Bucer, and the Swiss reformers. The schism of Henry VIII. paved the way, but it did not originate, nor promote, nor establish the doctrines of the Reformation; they made their way rather in spite of, than by the favour of, that capricious king. It was only under his successor, Edward VI., that the Reformation became established by authority. Still the origin of the Church of England as a body independent of Rome dates from the wayward deeds of Henry VIII., and when that Church afterwards adopted the reformed doctrines, there was a great admixture of political and state reasons in the final establishment of it, especially under Elizabeth, and consequently much severity and harshness were exhibited towards those who adhered to the old religion, which threw for a time a dubious light over the ascendancy of the Reformation in England.

For its progress and final settlement, we must refer to the histories of this country, and the articles Bucer; Cranmer; Cromwell, Thomas; Edward VI.; Elizabeth of England; Gardiner; Henry VIII.; Mary I. of England; and Pole, Reginald, in Biog. Div. For the Reformation in Scotland, see Knox and Mary Stuart, in Biog. Div.

In France, as early as 1530, the doctrines of the Reformation had found their way from Germany and Switzerland. Some of those doctrines had lingered in the south for ages before, especially in the mountains of Dauphiné bordering on the Valdenses. Pierre Robert d'Olivet, Michel Cop, rector of the University of Paris, Beza, and others, adopted and spread them; and Margaret, sister of Francis I., and Renée, daughter of Louis XII., gave them their countenance. But Francis I., who through policy secretly encouraged the Protestant states of Germany against the emperor, persecuted his own subjects who had embraced the new doctrines. The stake and the faggot were employed at the same time in France and in England, by Francis and Henry VIII., against the Reformers. In 1535, Francis, attended by his family, the clergy, the magistrates, and other officers of state, was present at the burning by a slow fire of six citizens of Paris, who had been condemned by the parliament as heretics. The execution lasted two hours. This was the forerunner of many scenes of a similar character which disgraced France for more than half a century. The persecutions, the civil and religious wars, the truces and other vicissitudes of the French Calvinists, during the reigns of Francis I., Henri II., Francis II., Charles IX., and Henri III., are part of the history of France. De Thou, in his 'Historiæ sui Temporis,' Beza, 'History of the Reformed Churches of France,' and the 'Mémoires et Correspondence de Duplessis Mornay pour servir à l'Histoire de la Reformation et des Guerres civiles et religieuses en France depuis l'an 1571 jusqu'en 1623,' Paris, 1824–34, are the best contemporary authorities for that period. At last, Henri VI., by his 'Edit de Nantes,' 1598, acknowledged the Reformed communion as the lawful creed of a part of the French population.

The doctrines of the Reformation had made many converts in the Netherlands in Luther's lifetime, and a fresh influx of Calvinists from France and Switzerland increased the number of dissidents from the Roman Church. The wild outbreak of the Anabaptists at Leyden, Münster, and other places, threw discredit for a time on the cause of the Reformation; but these disturbances were soon put down. During the reign of Charles V., the friends of the new doctrines in the Netherlands were persecuted as heretics, and many suffered death by sentence of the regular courts of the country; but after Charles abdicated, at Brussels in 1555, in favour of his son Philip, the latter, in order to extirpate heresy more effectually, sent inquisitors from Spain to establish the tribunal of the Holy Office in the Netherlands. This gave rise to a strong opposition both from the nobles and the people, which, being mixed up with political grievances, led to an open insurrection against Philip. During the long war which followed between the rebels and the Spanish forces, some of the provinces separated from the rest, and the seven northern provinces of Holland, Zealand, Guelderland, Friesland, Utrecht, Overyssel, and Groningen formed a confederacy by the name of the "Seven United Provinces," and proclaimed liberty of conscience. The great majority, however, of the population of the seven provinces followed the doctrines of Calvinism, and have remained attached to them ever since. The confession of faith for the provinces of the Netherlands was published in 1562, and was afterwards approved by the members of the synod of Emden in 1571. The disputes that broke out afterwards between the Arminians and Gomarists are related in the article ARMINIUS, in BIOG. DIV. The synod of Dort, in 1618, revised and republished the Netherlandish confession.

About the year 1556 the Lutheran or Protestant creed was adopted as the state religion in the kingdoms of Denmark and Norway, under King Christian III. Denmark, however, as well as Sweden, has retained episcopacy.

The Protestants or Lutherans, as well as the Calvinists, became very numerous in Poland under the reign of Sigismund Augustus, and many of the high nobility had embraced the Reformed doctrines. An approximation was effected between the Lutherans and Calvinists, and a confession was drawn up, in concert, by the clergy of both communions, at Sandomir, in 1570, called "Consensus Sandomiriensis." The followers of the Reformation, however, never constituted the majority in Poland, and being afterwards persecuted under Sigismund III. and some of his successors, their number was greatly reduced; but they were never annihilated, and Lutheran and Calvinist congregations have continued to exist in most towns in Poland. The most complete account of the Reformation in Poland is in the 'Historical Sketch of the Rise, Progress, and Decline of the Reformation in Poland,' 1838, by Count Krasinski.

In Hungary and Transylvania both Lutherans and Calvinists were established early, and they constitute a considerable proportion of the population of those countries. The recent attempt of the Emperor of Austria to repress them and to abolish their privileges, has led to discontents, aggravated also by other infringements on the constitutional rights of the people, of which the results are yet (1861) uncertain.

The doctrines of the Reformation spread into Italy from Switzerland and Germany at an early period, and found proselytes in several towns, especially Ferrara, where Renée of France, duchess of Este, countenanced them; at Lucca, Faenza, Milan, and Naples. Several learned monks and priests,—the Capuchin Ochino of Siena; Vermigli, a canon of Florence; Montalcino, a Franciscan friar; Lorenzo Romano, an Augustine monk, and others,—adopted and preached the new tenets. Meetings and private places of worship were established in various towns. Paul III., alarmed at this change, established, in 1543, the Congregation of the Holy Office at Rome, with full powers to proceed against heretics independent of the ordinaries; and he also sent inquisitorial commissioners into the various provinces of Italy for the same purpose. By these means he effectually checked the course of the Reformation, and his successors Paul IV. and Pius V. completed its extirpation by the most severe measures. Many of the followers of the Reformed doctrines suffered death either by fire or by the sword of the executioner. [PIUS V., in BIOG. DIV.] Numerous families emigrated to Switzerland on account of religion, especially from Tuscany and Lombardy. A considerable district of Calabria, near Cosenza, which is said to have been originally peopled by a colony from the valleys of Piedmont, having publicly adopted the tenets of the Reformation, and sent for some Calvinist preachers from Geneva to teach them and their neighbours, the Duke of Alcala, Spanish viceroy of Naples, about 1560, sent several inquisitors with a body of armed men, who arrested and put to death many people in the village of San Sisto. Upon this the neighbouring villages broke out into open revolt. The town of La Guardia Lombarda sustained a regular siege. Being taken at last, a general massacre of the inhabitants took place, with circumstances of the greatest atrocity. (Botta, 'Storia d'Italia,' b. x.)

In Spain, the doctrines of Luther and Calvin spread in the 16th century, and made numerous proselytes at Seville and other places; but the arm of the Inquisition effectually eradicated them. M'Crie has written the history of the rise, progress, and extinction of the Reformation both in Spain and in Italy.

Among those authors who have written or commented upon the history of the Reformation, the following deserve notice:—Among the Protestants—Sleidan, *De Statu Religionis et Reipublicæ, Carolo quinto Cæsare Commentarii*, first published in 1555, and translated into English by E. Bohun, with a continuation to the end of the Council of Trent in 1562, and published in 1589; Spalatinus, *Annales Reformationis;* Beausobre, *Histoire de la Reformation;* Burnet, *History of the Reformation;* Seckendorf, *Commentarius Historico-Apologeticus de Lutheranismo;* Loscherus, *Acta et Documenta Reformationis:* and among the Roman Catholics — Maimbourg, *Histoire du Lutheranisme;* Pallavicini, *Historia Concilii Tridentini;* Bossuet, *Histoire des Variations des Eglises Protestantes;* besides the general historians of the Church.

REFORMATORIES. By the Acts 17 & 18 Vict. cc. 86 and 169, and 20 & 21 Vict. cc. 48 and 109, various provisions are made by which magistrates may send juvenile offenders to reformatories, instead of to prison, there to be detained for certain periods, at the discretion of the magistrate before whom the young delinquent is charged. The reformatories must be inspected and certified by a government inspector before they are legally entitled to receive juvenile offenders under the Acts referred to. Parents who have sufficient means are bound to pay a certain amount towards the expense of maintaining their children while detained in reformatories. Several reformatories for adult criminals, both male and female, are likewise in operation. In 1856 an institution called the Reformatory and Refuge Union was established in London, for the purpose of promoting the extension of reformatory operations. From a statement published by this Union, it appears that there were at the commencement of 1860, in England and Wales, 57 reformatories, with accommodation for about 4500 inmates; in Scotland 17, with accommodation for 1840 inmates; and in Ireland 6, with accommodation for 680 inmates. The accommodation indicated by these figures does not show the actual number of inmates at the time referred to, as many of the houses were only partially occupied.

The reformatory best known, and on the largest scale in this country, is that of the Philanthropic Society at Red Hill, near Reigate, Surrey. The founder of the Philanthropic Society, Robert Young, commenced his efforts on behalf of the children of criminals in 1788. He took in succession four small houses at Hackney for their reception, and placed in each a mechanic or artisan to instruct them in useful labour. The society was incorporated in 1806, and increased in importance and in usefulness. For the last eleven years its extensive operations have been carried on at Red Hill, where the society's farm occupies an area of about 240 acres. By the Act of Incorporation, the objects of the society are defined to be the children of convicted felons, or children who have themselves been guilty of criminal practices; and of late years admissions have been principally of the last class, especially juvenile offenders sentenced to detention under the Act 17 and 18 Vict. c. 86, and 19 & 20 Vict. c. 109. To be eligible for admission, the boy must be under fifteen years of age, of sound bodily health, and capable of receiving mental instruction and industrial training. By special arrangement, this institution receives juvenile offenders from the eastern division of the county of Sussex, from the counties of Surrey, Somerset, Notts, Salop, Lincoln, Montgomery, and Oxford; from the Isle of Ely; from the boroughs of Nottingham, Hastings, Brighton, and Reading; and from the city of London. In consideration of the voluntary subscriptions received from the public, a limited number of boys are received into the establishment free of charge. The number of boys under the society's care at one time is usually about 260; they are divided into five sections or "families," each with a separate house, and a master or "father." This plan was adopted from the system so admirably carried out at Mettray by M. Demetz, although, the families at Red Hill being larger in number than those at Mettray, the control of the master is not so effective. The separation of the families, however, is so well kept up that, except at chapel, many of the boys never see each other. The boys learn and work alternately, half of the number being at school while the other half are employed as shoemakers, as tailors, as assistants in the dairy, in brickmaking, or at farm-work. Each school has a playground attached. There is also a bathing-pool, which, under proper regulations, is frequently used. The boys generally enjoy good health. The establishment is made to produce as much for its own support as possible: thus all the shoes, clothes, &c., required for the boys are made in their own workshops; grain, potatoes, and garden-stuffs are raised on the farm; the dairy supplies the milk and butter required, and is in such repute that the surplus produce is in great demand in the neighbourhood. Bread is made on the establishment. It is pleasing to visitors to observe the excellent feeling which prevails between the boys and the masters and the officers of the institution. The conduct of the boys at chapel is exceedingly decorous: in giving the responses, and in accompanying with their voices the neat little organ placed in the chapel, they manifest a gratifying amount of earnestness. Forty-five of the boys were confirmed by the Bishop of Winchester in May, 1859. The disposition of the boys may to some extent be judged of from the circumstance that, of 159 boys who were out on leave during 1859, only 4 did not return to time. Nineteen deserted the school during the year. Five had to be committed to prison.

Among the sources of income of the Philanthropic Society, the following may be noticed:—The profit of the farm-work in 1859 was 448*l.*; on brick-making, 106*l.* The amount of work done by the boys for employers in the neighbourhood was 156*l.*; while upwards of 6000*l.* was received from government under the Reformatory Acts. The outlay for training and maintenance was, on an average, about 20 guineas for each boy; the total expenditure was 7200*l.*

The number of boys received during 1859 was 99; of these about half had lost father or mother, or both; many were the children of drunken and immoral parents. Of those discharged during the year, 43 emigrated, 6 were apprenticed, 5 sent to service, 4 to sea, and 35 were sent to friends. About 900 boys have been sent out as emigrants to Canada, the United States, and Australia, since the commencement of the school. From a statement showing the disposal of the boys during four years, 1855–1858, it would appear that about 11 per cent. of the emigrants, and about 28 per cent. of those in home employments, relapsed into crime.

Much of the success of the Philanthropic Society's operations is due to the excellent management of the Rev. Sydney Turner, now government inspector of reformatories, who was chaplain and secretary to the institution for a number of years.

The following reformatories are in operation in and near *Bristol*:—Kingswood (established 1852), for 100 males; Red Lodge (1854), for 60 girls; Arno's Court (Roman Catholic, 1856); for 300 females. The *Liverpool* Farm School, situated at Newton, near Warrington, with accommodation for 80 boys, was established in 1859. The magistrates in Liverpool have taken pains to apply the provisions of "The Youthful Offenders Acts," and the results have been highly satisfactory. In the five years preceding the passing of these Acts the average number of juvenile offenders committed to prison was 1030; in the five years following the average fell to 751; the highest number was 1148 in 1852; the lowest 486 in 1858. The daily average of juveniles in prison in 1854 was 110; in 1859 it was a fraction under 25. The gangs of juvenile offenders which formerly infested and plundered the town have been quite broken up. Parents have been called upon, in accordance with the provisions of the Acts, to pay towards the expense of thus reforming and training the children they have neglected, the amount reaching, on an average, about 250*l.* a year. *Exeter* had a Female Refuge for discharged prisoners of the Western Counties as early as 1836, with accommodation for 20 inmates: it has now, in addition, the Devon and Exeter Reformatory Farm School, at Brampford Wood, founded in 1855, for 30 boys, and the girls' reformatory for the Western Counties, for 50 inmates, commenced in 1858. The Castle Howard Reformatory, at Welburn, near *York* commenced in 1856, with accommodation for 80 boys, receives youths sentenced to detention who have been previously once, or oftener, convicted, from the North and East Ridings, the City of York, and the town of Hull. The boys are employed chiefly in spade husbandry, and are much in request as labourers by the farmers in the neighbourhood. The number of juvenile offenders in the North and East Ridings has greatly diminished since the opening of the school. With respect to the town of Hull, the testimony of the sitpendiary magistrates is, that "juvenile crime, as a system, is broken up." The *Manchester* and *Salford* Reformatory, at Blackley, has accommodation for 50 boys. At *Birmingham*, the Saltley Reformatory Institution, Small Heath, has accommodation for 100 boys; and the Smethwick Reformatory has accommodation for 45 girls. At *Wakefield*, the West Riding Reformatory School for girls was commenced in 1856.

REFRACTION, REFRANGIBILITY. Refraction is the turning of a ray of light, heat, or other imponderable substance from its direction, when it falls obliquely on the surface of a medium differing in density from that through which it had previously moved. The differently coloured rays of light have different degrees of refrangibility, as evidenced by the common prismatic spectrum; in other words, the refractive indices of different lights vary for a given medium. The fundamental law of refraction and the optical effects of this law are discussed under the heads LIGHT and OPTICS, and a table of refractive indices is given in the article OPTICS, PRACTICAL. For the different refrangibilities of the rays, the articles DISPERSION and ACHROMATIC may be consulted, and for one of the most striking phenomena thence arising see RAINBOW. On the subjects of Fraunhofer's lines and of double refraction, see DISPERSION and UNDULATORY THEORY.

The doctrine of refraction, as distinguished from reflection, is called dioptrics, and the caustics formed by the continued intersections of refracted rays emanating from a luminous point, are termed diacaustics; properly speaking, these are surfaces, but by confining the investigation to the plane of refraction, they are generally treated as curves. A diacaustic curve, like a catacaustic, has the property of being rectifiable. They are noticed in the articles above quoted, but they are rather objects of analytical dexterity than of practical use.

So long as the medium into which the refracted ray enters remains of uniform density, the ray will pursue a straight course, but every alteration of density in the medium gives rise to a corresponding deviation in the path of the ray. Now the air is a medium of which the density continually increases as its altitude above the surface of the earth diminishes; its density is also altered in the same stratum by inequality of temperature, and frequently from the aqueous and other vapours which it holds. Hence arise the ordinary terrestrial refraction and the phenomena of Mirage, Fata Morgana, &c., which are treated under their respective heads.

A ray of light proceeding from a star which is not vertical, on entering the atmosphere is bent towards the radius drawn from the earth's centre to its point of incidence, and upon its successive incidences on the lower strata it continues to bend towards the successive radii, thus describing a curvilinear trajectory through the air. The star is visible in the direction of the tangent to this curve, at the point at which it meets the eye of the spectator; hence the apparent altitude of the stars is increased by refraction, and thus the sun, moon, &c., are visible before the real time of rising and after that of setting.

From the causes above assigned for atmospheric refraction, it follows that the nearer the direction of the ray is to the plane of the horizon, the greater is its refraction, and the refraction is nothing when the ray is vertical. This is the cause of the apparently oval forms of the sun and moon in the horizon; for the sun's angular diameter being taken at 32 minutes, its lower limb is elevated through horizontal refraction more than its upper by 4 minutes 54 seconds.

Atmospheric refraction of the solar rays after sunset, combined with subsequent reflection, is the cause of twilight, and also of the light thrown on the moon's surface when eclipsed by the earth.

The amount of refraction of rays proceeding from a celestial body would be proportional to the tangent of its zenith distance, if the atmosphere were homogeneous, and the zenith distance sufficiently small to allow us to regard the refracting strata of air as bounded by parallel surfaces. Not only, however, is the atmosphere defective in homogeneity, but its state is continually altering, as shown by the barometer, thermometer, and hygrometer. A partly empiric formula, the result of numerous observations made by Bradley, gives a good correction relative to the first two of these instruments, namely:—

Let $r = 57'' \times$ tang. zenith dist. (z);
$h =$ height of thermometer (Fahrenheit);
$a =$ altitude of barometer in inches.
$\text{R} =$ the required refraction; then shall

$$\text{R} = 57''.\ \frac{a}{29{,}6} \cdot \frac{400}{350+h} \cdot \tan\,(z - 3r) \text{ nearly.}$$

Similar formulæ have been the objects of analytical research to Laplace and other modern mathematicians; their results are however not well adapted for insertion in this work.

REFRACTION, DOUBLE. [POLARIZATION OF LIGHT.]

REFRIGERANTS are remedial agents which directly diminish the force of the circulation, and reduce the heat of the body or a portion of it, without occasioning any diminution of the ordinary sensibility or nervous energy. This definition must not be considered as excluding *cold* from among the number of such agents, because it is capable, when carried to extremes, of rendering the sensibility null, and utterly extinguishing the nervous power; it is only its moderate and therapeutical employment which is here contemplated. Cold, however, has of late been recommended to be carried locally to an extreme degree, utterly destroying for a time and special purpose the sensibility, thus acting as an anæsthetic. It is likewise applied to the spine with much benefit in some cases of tetanus.

The manner in which refrigerants effect the ends which they accomplish is far from being understood; and a remarkable feature in their character is, that they display their peculiar effects chiefly when the action of the organs is above their natural standard, and more heat than natural is evolved. Till we have a perfect knowledge of the sources and mode of formation of animal heat, we are not likely to possess a correct theory of their mode of operating; and at present, whatever plausibility the mere chemical hypothesis of Dr. Murray exhibits, we cannot consider the evolution of animal heat to be other than a vital process. This function is mainly carried on in the capillaries or extreme vessels, and is much influenced by the amount of supply of nervous energy to these vessels. Hence, when a limb is paralysed, it is colder than the opposite sound member; or when a single nerve is injured, the parts supplied by it have a lower temperature than the surrounding ones. Whatever, therefore, hinders the free communication of the nervous power to a part or to the whole system, will lessen its quantum of animal heat. By applying to the surface of the body any acid, the calibre of the capillaries is lessened, and hence the paleness which is observed, owing to less blood entering them. As the blood furnishes the pabulum from which the nerves evolve the heat, the less fuel the vessels contain, the less potent will be the heat resulting. The introduction of any article of the class of refrigerants into the stomach appears to operate by sympathy on the whole vascular system, as may be seen in the case of dilute sulphuric acid checking hæmorrhage. The agents which are usually regarded as refrigerants are weak vegetable acids, or very greatly diluted mineral acids; some saline, neutral, or super salts; and cool air, ice-cold water, and externally evaporating lotions. An indirect refrigerant is found in diminishing the quantity of animal food. [ANTIPHLOGISTIC TREATMENT; BATHING; LOTIONS.]

REFRIGERATION OF THE GLOBE. Since the mathematical researches of Fourier regarding the diffusion and conduction of heat in a mass constituted as the earth appears to be in the parts near the surface, have become in some degree known, geologists have been much encouraged in attempting to connect with a gradual change and diminution of the internal temperature of the globe, such as would be consistent with Fourier's theoretical results, the higher order of geological inferences. The phenomena of a general if not universal base of once melted rocks below all the strata, the peculiar (often called metamorphic) condition of the lowest of these as compared with the upper, the absence or rarity of fossils in the lowest strata, the evidence of even general high surface temperatures on the ancient land and in the ancient sea as contrasted with the modern distribution of climates, are all consequences supposed to be derivable from the assumption of the earth having once been thoroughly very hot, and being now partially cooled by radiation of heat into the cold planetary and stellar spaces around us. But though such a deduction of phenomena from a primal condition of our planet is or appears to be correct enough to justify geologists in employing the hypothesis as a means of discovering truth, they must be careful neither to disregard inquiries into the certainty of the fundamental assumption, nor to neglect a scrupulous examination of its consequences.

On the first point Professor Whewell communicated to the Geological Section of the British Association at Dublin (1835), some observations which are likely to be influential on the second point, and which can neither be condensed nor amended.

"The heat of the interior parts of the earth has always been treated of by those who have established the theory of heat upon mathematical principles. They have hitherto considered it as proved upon such principles, that the increase of temperature of the substance of the earth as we descend proves the reality of an *original heat*. But M. Poisson, in his 'Théorie de la Chaleur,' just published, dissents from this opinion, and is disposed to assign another reason for the higher temperature below the surface. He observes that the cosmical regions in which the solar system moves have a proper temperature of their own; that this temperature may be different in different parts of the universe; and that, if this be so, the earth would be some time in acquiring the temperature of the part of space in which it has arrived. This temperature will be propagated generally from the surface to the interior parts. And hence, if the solar system moves out of a hotter into a colder region of space, the part of the earth below the surface will exhibit traces of that higher temperature which it had before acquired. And this would by no means imply that the increase of temperature goes on all the way to the centre." ('Report of the British Association for 1835,' p. 66.)

A speculation, perhaps in reality involving such views as those of M. Poisson, though founded on examinations and inferences among the Helvetic Alps, was subsequently brought prominently before the geological world by M. Agassiz. According to this very distinguished naturalist, there is evidence from the peculiar effects left by glaciers, in the valleys of Switzerland and on the surface of the Jura Mountains, that the icy mantle which now wraps the High Alps once filled the valleys for miles beyond its present limits, and, consequently, that the blocks of Mont Blanc and the Valorsine were carried across the Lake of Geneva to the Jura, by a mere glacier movement across an ice-filled hollow. Dr. Buckland and Mr. Lyell have endeavoured by similar evidence and reasoning, by the evidence of scratched, smoothed and grooved surfaces of rock, and the appearance of moraine heaps in the Highlands of Scotland, near Edinburgh, and in Cumberland and Westmoreland, to prove that glaciers anciently covered large tracts of the Caledonian and Cumbrian regions. ('Geol. Proceedings,' 1840, November and December.)

Moreover, it is understood to be the opinion of M. Agassiz that the icy covering thus attempted to be demonstrated by its remaining effects in the mountainous parts of Great Britain, "once extended over all the north of Europe and the north of Asia and America," and that in this "mass of ice the elephants and other mammalia found in the frozen mud and gravel of the arctic regions were imbedded at the time of their destruction." To the quick melting of this immense mass of ice and the currents of water which resulted, the author attributes the transport and deposition of the "masses of irregularly rounded boulders and gravel which fill the bottom of the valleys, innumerable boulders having at the same time been transported, together with mud and gravel, upon the masses of the glaciers then set afloat." (See the work of M. Agassiz, entitled 'Etudes sur les Glaciers de la Suisse,' and the accounts of his observations before the British Association at Glasgow in 1840.)

Now it is obvious that in examining this speculation, two ways are open: first, a careful comparison of the phenomena with the hypothesis which is proposed for their explanation; secondly, an inquiry into the probability of the conditions which might render such a general and extreme refrigeration of the globe as the hypothesis requires *possible*. Confining our remarks to the former process, we may observe: first, that to admit the ancient existence of glaciers in some of the Highlands and Cumberland valleys which display *glacial effects*, is one thing; to admit *glacial action* as the physical cause of the dispersion of boulders and gravel, another. Glaciers are found at this day in corresponding latitudes and at corresponding elevations in the southern parts of America; a local effect of causes which may be conceived to have formerly produced an equal effect in the northern zone: but the distribution of the boulders and gravel is so peculiar and yet so various, the dispersion of them so wide in regions where, according to the present configuration of the land, they could not be pushed by glaciers, nor carried by floating ice; and the connection of these circumstances with a great change of organic life, so strict, that it is hardly conceivable such effects could be due to anything but a cause simultaneously general or successively repeated. Of the physical causes by which the explanation of this great phenomenon has been attempted, it will suffice to mention three:—

1. Great and extensive oceanic action consequent on mighty misplacements of the solid land, and corresponding changes of land and sea.

2. Repeated local displacements of land and sea, and consequent litoral action.

3. The melting of great circumpolar glaciers, and the drifting of floating ice.

During the period of nearly twenty years which has elapsed since the first publication of the preceding portion of this article, much has been done on the subject, both by mathematicians and geologists. The consequences of admitting the hypothesis of the refrigeration of the globe, and the history of the gravel containing sea-shells alluded to above, and now called the "northern drift," have been rigorously investigated. Until within this period, the only change of climate which had been recognised by geologists as having taken place during the earth's geological history was one from a higher to a lower temperature; and for those who believed in the primitive heat of the globe, however originated, that heat afforded one obvious cause for this higher temperature at remote geological epochs. When, however, an examination of the phenomena of the "glacial epoch" (first conceived by Agassiz) during and on the gradual termination of which that drift was accumulated, rendered it necessary to recognise a change of climate in our own region of the globe (as indicated by the facts noticed in the proposition 1 above) from a lower temperature during that period to a higher subsequent temperature, new conditions were added to the problem. As we have seen, two other causes had been already suggested, which might possibly account not only for a change from a higher to a lower superficial temperature, but also for oscillatory changes. One of these assigned causes rested on the fact of the translatory motion of the whole solar system in space, and the hypothesis proposed by Poisson of the variable temperature of the different regions through which it might pass; thus the other cause assigned, pointed to in propositions 1 and 2 above, was the influence of different configurations of land and sea on the climatal state of particular portions of the earth's surface. No attempt, however, was made to examine the efficiency of these different causes to account for all the phenomena which might be referable to them, until Mr. William Hopkins, F.R.S., of St. Peter's College, Cambridge, when president of the Geological Society of London, undertook a remarkable investigation contained in a paper communicated to that society in 1851, and published in its 'Quarterly Journal,' vol. viii., pp. 56—92, 'On the Causes which may have produced Changes in the Earth's Superficial Temperature.' He also returned to the subject in his anniversary address to the society in the following year, printed in the same volume. From these papers is derived the following view of what may be regarded as the actual condition of the theory of the refrigeration of the globe; but we have stated the subject in a somewhat different order from that adopted by the author.

If there be any propositions in experimental science which may be deemed incontrovertible, the following, Mr. Hopkins conceives, is one of them:—"If a mass of matter—such, for instance, as the earth with its water and its atmosphere—be placed in space of which the temperature is lower than its own, it will necessarily lose a portion of its heat by radiation, until its temperature ultimately approximates to that of the circumambient space, unless this reduction of temperature be prevented by the continued generation of heat." This proposition, it will be seen, is equivalent to an explicit statement of the theory of the refrigeration of the globe in all its generality. Now, assuming the primitive temperature of the globe to have been very much greater than at present, there is manifestly no difficulty in accounting for any higher superficial temperature than the present, at past epochs, provided those epochs be sufficiently remote. They must, however, be exceedingly remote to enable us thus to account for a variation of temperature which should sensibly affect the climatal conditions in any part of the earth. If the cooling of the earth were to continue for an indefinite period of time,—assuming the temperature of external space, the sun, and the earth's atmosphere to remain as at present,—the superficial temperature would approximate indefinitely near to a certain limit. The difference between that limit and the earth's present superficial temperature is the effect due to the remains of the primitive heat. Theory gives us a simple relation between the amount of this effect and the rate of increase of temperature in descending beneath the earth's surface. Knowing the one, we can immediately determine the other, and thus, having ascertained the rate of increase, we know the amount of superficial temperature which is now due to the earth's primeval heat, assuming always that heat to be the cause of the existing internal temperature of the globe. This amount is thus proved not to exceed about the one-thirtieth part of a degree of the Centigrade thermometer, so nearly has the earth's superficial temperature approximated to that ultimate limit beyond which it could never descend, supposing external conditions to remain the same. It has been shown, on high mathematical authority, that to reduce the superficial temperature of the earth by one-half of the above amount, or one-sixtieth of a centesimal degree, it would require the enormous period of *one hundred thousand millions of years*. "It would doubtless," says Mr. Hopkins, "require us to go back into the past some such immense period as this to arrive at the epoch when the superficial temperature should have exceeded its present amount by even one or two degrees. At the same time, the rate of increase of temperature in descending beneath the surface would be much more rapid than at present. [The present rate is about 1° Fahr., or $\frac{5}{9}$° C. for every 60 feet of depth.] If the superficial temperature amounted to 2 C. above its ultimate limit, instead of having $\frac{1}{30}$th of a degree, the rate at which the temperature would increase in descending would be about sixty times as great as at present; that is, there would be an increase of 1° C. for little more than 1 foot of depth."

"It must be recollected that this state of terrestrial temperature, if due to the cause we are considering," that is, to the refrigeration of the globe, "could only have existed at times which, even in a geological sense, must have been extremely remote. The important peculiarity of this state of the earth would seem to consist in the simultaneous existence of a superficial temperature, and therefore of climatal conditions, very nearly the same as at present, with an internal temperature at the depth of a few hundred feet and upwards, immensely greater than at present."

With regard to the reason assigned by Poisson for the higher temperature below the surface of the earth and its changes, as cited above in Dr. Whewell's observations, Mr. Hopkins remarks: "What may have been the possible effect of this cause in the lapse of indefinite time, it is impossible to say; but I cannot understand how it could be very considerable without a totally different distribution of the group of stars to which the sun should belong, or the near approach of the solar system to some individual star. The latter hypothesis, however, would be inconsistent with the integrity of the solar system as it now exists, if we suppose the proximity to any single star to become such as to produce any material modification of terrestrial climate; and perhaps it may be difficult to conceive how the first hypothesis should escape a similar objection. At all events it may be regarded as certain that according to neither of these hypotheses can any considerable effects have been produced by this cause on terrestrial temperature within the later Tertiary period, and that we cannot thus account for the cold of the glacial epoch."

With respect to the third supposed cause of changes in the earth's superficial temperature, we need not follow Mr. Hopkins, as it does not belong to the subject immediately before us; his masterly exposition of it will be found in the papers already cited. For the special history of the glacial epoch, we may refer to Sir C. Lyell's 'Manual of Elementary Geology,' fifth edition, ch. xi. and xii. Mr. Hopkins, in continuing his researches in physical geology, has investigated the effects due to the remains of the earth's "primitive heat;" an account of his results, together with the principal known facts of the earth's internal temperature, will be given in the article TEMPERATURE, TERRESTRIAL, DISTRIBUTION OF.

REFUGE, HARBOURS OF. In the year 1840 a commission was appointed "to visit the coast between the mouth of the Thames and Selsea Bill; to examine the ports on that coast with reference to their being rendered available as places of shelter for vessels passing through the Channel in cases of distress from weather, and also as places of refuge for merchant vessels from enemies' cruisers in time of war, and more especially as to their being made stations for armed steamers employed for the protection of our trade in the narrow parts of the Channel." The commission made a report, but no measures appear to have been taken in consequence.

A select committee of the House of Commons on shipwrecks, in a report presented in 1843, recommended the formation of harbours of refuge in the British Channel, at the same time stating that they refrained from pointing out any particular situations for such harbours, from a conviction that such situations would be best decided by a body of scientific and experienced persons whose attention should be specially and exclusively directed to the subject.

On the 2nd of April, 1844, the Lords of the Treasury, on the suggestion of Sir Robert Peel, then First Lord of the Treasury, appointed a commission consisting of twelve experienced naval and military officers and civil engineers to inquire into the most eligible situations for a harbour or harbours of refuge in the Channel.

The report of the commissioners is dated August 7, 1844, and was presented to the House of Commons pursuant to an address dated March 6, 1845. The treasury minute under which the commissioners acted assigned three principal objects of investigation:—1, the selection or formation of harbours of refuge for the safety and convenience of vessels navigating the Channel; 2, that in times of war, such harbours might become stations for ships of war; 3, the expense of constructing new works, as compared with the public advantages likely to result from such works. The commissioners express their unanimous conviction that additional means of protection for the south-eastern coast of England are absolutely necessary. The harbours between Portsmouth and the Thames are only tidal harbours, and none of them are at present accessible to large steamers. The report recommends certain ports and positions as harbours of refuge and roadsteads, and certain breakwaters and military defences in connection with them, so as not only to afford shelter to merchant ships, but also to provide means by which, with the advantages of steam by sea, and railroads and telegraphic communication by land, the naval and military force of the country may be thrown on any point of the south-eastern coast in a few hours.

The following harbours and positions were especially examined:—Foreness, near the North Foreland; Ramsgate; the Brake, or Small Downs; Dover; Dungeness; Beachy Head, Eastbourne, and Seaford; Newhaven; Portland and Weymouth; Harwich Harbour. Of these places four are selected, Dover, Seaford, Portland, and Harwich, of which the commissioners estimated the expense required for the construction of the works which they recommended as follows:—Dover, 2,500,000*l.*; Seaford, 1,250,000*l.*; Portland, 500,000*l.*; Harwich, 50,000*l.* It was recommended that Dover Bay should be converted into a large harbour by means of breakwaters, with an area of 520 acres up to low-water mark, and an entrance 700 feet wide on the south front and another 150 feet wide at the east end. Its situation, four miles and a half from the Goodwin Sands, and standing out favourably to protect the navigation of the narrow seas, is peculiarly suitable as a station for a squadron of ships of war. It was recommended to construct a breakwater in Seaford Road, for the protection of trade and as a station for armed vessels. Portland, as the boundary of the narrow part of the Channel, and with reference to the Channel Islands, was recommended as another station for a squadron. The construction of a breakwater there, it was stated, would be easy, cheap, and expeditious, as a large part of the island facing the bay is crown property, and contains abundance of stone: the holding-ground is exceedingly good, and the island has abundance of water for the supply of ships. The island has great natural advantages for defence, and for the formation of a naval and military depôt during war to any extent that may be required. Harwich Harbour, formed by the junction of the rivers Stour and Orwell, was stated to have sufficient depth of water and good holding-ground over an extent capable of containing many hundred ships. By the construction of a breakwater and dredging to get rid of certain shoals, the commissioners considered that it might be converted into one of the finest and most useful harbours in the kingdom.

The military members of the commission recommended that casemated batteries should be constructed on the breakwaters themselves, supported by defences on the shore flanking the approaches to the breakwaters and harbours.

Such is a sketch of the report upon which our government has acted, and in some of its details it is so utterly ridiculous that the nation has reason to blush for the appearance our official science must bear in the eyes of foreigners; nor have the results actually attained by the works executed been much superior to the so-called scientific reasoning on which they were based. The works at Harwich have been completed, and already the laws of the tides on this part of the coast have produced the silting-up which ought to have been foreseen. At Dover, the works proceed slowly and with difficulty; but already it has been found that they have produced an alteration in the flow of the littoral current, and in the advance of the shingle, which has endangered the stability of the present shore of the west side of the bay. Any one accustomed to watch the action of marine currents must have known that such would have been the case; but then such a person would never have dreamt of judging these questions by the analysis of some bottles of sea-water. Sir W. Symonds was perfectly correct in his view of the question, and if it were necessary that a great expense should be incurred in the formation of a new harbour of refuge on this coast, it should be placed near Dungeness, or at the mouth of the Ouse, near Newhaven—without, of course, neglecting the improvement of Dover harbour. The works at Portland have been more successful than those at Dover, or at Harwich, or at Alderney; and those undertaken at Holyhead seem at present to enjoy a very equivocal reputation.

Meanwhile the want of harbours of refuge on the south and the east coast of England continues to be felt; for between the Tyne and the Humber, and between the Humber and the Thames, there is no safe refuge; nor can a vessel of great draught of water find any shelter in the British Channel between the Solent and the Thames. This is a national question; and it is one which it behoves our legislature at once to grapple with, in the interest of our now unprotected commercial marine.

The commission of 1840 recommended three places as suitable for harbours of refuge—Dover, as first in importance; Beachy Head, as second; and Foreness, as third.

(*Report of the Commissioners upon the Subject of Harbours of Refuge*, 1845.)

REGALIA, the ensigns of royalty. This term is more especially used for the several parts of the apparatus of a coronation. In England, the regalia properly so called are the crown, the sceptre royal, the virge, or rod with the dove, St. Edward's staff, the orb or mound, the sword of mercy, called Curtana, the two swords of spiritual and temporal justice, the ring of alliance with the kingdom, the armillæ or bracelets, the spurs of chivalry, and sundry royal vestments. The regalia here enumerated, all but the vestments, are preserved in the Jewel-Office in the Tower of London. Before the Reformation, in the time of Henry VIII., they were constantly kept by the religious of the abbey of Westminster; and are still presented before the king on the morning of the coronation by the dean and prebendaries of that church.

In 1649 a complete inventory was made out of the regalia in the Tower, a copy of which may be seen in the additional notes to Taylor's 'Glory of Regality,' (8vo., Lond., 1820; subsequent to which it is stated that the crowns, according to order of parliament, were "totallie broken and defaced." On the restoration of kingly government in the person of Charles II., new insignia were made for his coronation, and these, with the necessary alterations to accommodate them to their successive wearers, and to repair the injuries of time, have continued to the present day.

REGALS (*Regale*, It.), a small portable finger-organ, well known during the 16th and 17th centuries, and probably much earlier, but not now in use: though Snetzler, the celebrated organ-builder, informed the Hon. Daines Barrington, about the year 1770, that it was not then entirely lost in Germany ('Archæologia,' iii. 32); and till eighty years ago, if not later, there still existed an officer in the royal household called "Tuner of the Regalls." In Rees's 'Cyclopædia' this instrument is described as having "pipes of reeds for convenience of carriage," an error arising from a mistaken application of the organ-builder's term "reed stops," or stops in imitation of hautboys and other instruments blown through a reed.

REGENT, REGENCY. These words, like *rex*, contain the same element as *rego*, "to rule," *regens*, "ruling;" and denote the person who exercises the power of a king without being king, and the office of such a person, or the period of time during which he possesses the power. Wherever there has been hereditary sovereignty, or an hereditary kingly office, it has been found necessary sometimes to have recourse to the expedient of appointing a regent. The cases are chiefly those of (1) the crown devolving on a minor; (2) mental incapacity of the person in whom the kingly office is vested; (3) temporary illness, and incapacity in consequence; (4) absence from the realm. In the first case the regent has been called in England by the name of Protector: the latest instance being the minority of Edward VI.

The occasional absences of George I. and George II. on visits to their continental dominions rendered the appointment of regents a matter of convenience, if not of necessity. Sometimes the power was put, so to speak, in commission, being held by several persons jointly; but queen Caroline sometimes possessed the functions of regent during the absence of George II.

The nature of this part of the English constitution was however so little understood, and the practice was so imperfectly defined, that when George III. was incapacitated for discharging the duties of royalty on the first occasion when his malady became the subject of public notoriety, a question arose, on which the chief constitutional and political authorities of the time were divided in their judgment. The question was this—whether the heir apparent, being of full age, and the king's eldest son, did not become of right regent. One party, led by Mr. Fox, contended that he did. On the other side, it was maintained that it lay with parliament to nominate the person who should be regent. No regent was at that time appointed, the recovery of the king intervening. When the king was a second time incapacitated, all parties agreed in conferring the title, office, and privileges of regent on the Prince of Wales, then heir apparent. But it was done by parliament, who laid certain restrictions upon him during the first year; but in the event (which event did happen) of the continued incapacity of the king, he was to enter into the full possession of all rights and privileges of king, as if the king were dead, using however only the name of regent, not king: so that in reality the constitution of the country remained unaltered.

The time when the Prince of Wales held the office of regent is the period of English history usually called "the regency," just as "the regency" in reference to French history denotes the time of the minority of Louis XV., when the duke of Orleans was regent.

REGIMENT, a body of troops, whether infantry or cavalry, forming the third subdivision of an army; the union of two or more regiments or battalions constituting a brigade, and two or more of the latter making up a grand division or *corps d'armée*. A regiment is commanded by a colonel, a lieutenant-colonel, and a major; and when a regiment is divided into two or more battalions, each of these has, at least when complete, its own lieutenant-colonel and major. The word denotes, in general, any government; but it is now applied only to a body of men, indefinite in number, who are subject to military regulations, and immediately under the control of a colonel. The precise period when bodies of men were so designated for the first time is uncertain, yet no doubt exists that the common application of the term took place in France after the middle of the 16th century.

According to Père Daniel, the first formation of corps of troops corresponding in organisation to the modern regiments occurred in the reign of Henry II. of France; and that writer states ('Histoire de la Milice Françoise,' tom. ii., liv. xi.) that, very soon after the battle of St. Quintin (1557), in which the Constable de Montmorenci was defeated and nearly all the French infantry was dispersed, that king issued an ordonnance for the institution of seven legions of foot soldiers, each to consist of 6000 men, who were to be raised, or to do duty, in the frontier provinces of the kingdom. Each of these legions, which was commanded by a colonel, was divided into 15 companies, and to each of the latter were appointed a captain, a lieutenant, and an ensign. [COMPANY.] In this respect the legions differed from those which Francis I. had attempted to raise; for though each of the latter was to have consisted of 6000 men, it was to be commanded by six captains, one of whom only had the title of colonel; and under each captain there were to be two lieutenants and ten centurions. The legions of Henry II. were never completed to the extent prescribed by the ordonnance, and the number of companies in each was, soon after its promulgation, reduced to six.

Though these legions had most of the characteristics of a modern regiment, it appears that they were quite distinct from the bodies of troops which, about the same time, bore this name; and P. Daniel conceives that the regiments were first formed from the companies, or bands, as they were called, of which, from the time of Francis I., or earlier, to that of Henry II., the infantry of France chiefly consisted. Each of these bands was commanded by a captain, who, according to Brantome, was *mestre de camp* over his soldiers; that is, he had no officer above him except the colonel-general of infantry; and the bands were distinguished by the designation of old and new, according to the dates of their formation.

The embodiment of the bands in regiments could not, it is supposed, have been later than 1562, which was in the beginning of the reign of Charles IX.; and Daniel gives in support of this opinion the words of the historians Davila and Daubigné, who, in stating the events of the years 1562 and 1563, mention by name the regiments of Picardy and of Brittany; the former writer, also, in speaking of the renewal of the civil war in 1567, says that the queen sent in haste for the colonels De Brissac and Strozzi with the *old* regiments. These last are supposed by Daniel to have been the regiments formed of the old bands above mentioned, and to have been so called in contradistinction from others which may have been more recently raised. In proof that regiments then existed independently of the legions, he remarks that, in the registers of the French army for the year 1567, mention is made of an officer who was colonel of the legion of Picardy, and of another who is called colonel of the regiment of Picardy. The regiment of French guards was raised in 1563, by Charles IX., for the defence of his person; and the legions of Guienne and Dauphiné, which had been instituted by Henry II., and disbanded in 1562, were by the same prince restored under the name of regiments, the former in 1567 and the latter in 1568. Charles also organised other regiments, and it is probable that during his reign the denomination became general. The word *terzo*, which, according to Sir James Turner ('Pallas Armata,' 1683), was in his time applied by the Spaniards to a regiment, seems to indicate that the numerical strength of the latter was considered as equal to the third part of that of some other body, as a legion.

The time when the name and institution of a regiment were adopted in England cannot be fixed with precision; but Sir James Turner, in the work above quoted, remarks that the word regiment was not then a hundred years old; and if it is meant that the word had been nearly a century in use in this country, it would follow that it was introduced about 1583, or about twenty years after it began to be used in France. In the account of the pay of the officers of the army which was raised by Queen Elizabeth in 1588, when the country was threatened with the Spanish invasion, mention is made of the colonel and lieutenant-colonel of the regiment (Grose, 'Military Antiquities,' vol. i., p. 348); and both colonel and regiment occur in Morrison's account of the army in Ireland, in 1598. From the time of that queen's reign the British army has been invariably divided into regiments; and this practice has been followed by all the other nations of Europe.

The army which it was proposed to raise in 1620 for the protection of the Palatinate was to have been formed of 12 regiments of infantry, each consisting of 13 companies, of which the first, or the colonel's company, was to be composed of 200 men, and the others of 150 men; and there were to be 50 troops of horse, each consisting of 100 men. At this time, and perhaps earlier, the word battalion came into general use to denote either the whole or some division of a regiment. Sir Walter Raleigh, in his 'History,' calls the maniples of the Roman troops at the battle of Zama small battalions. Each of the four regiments of infantry which were raised by Charles I. to serve against the Scots consisted of 1850 men; and in 1659, during the civil wars in this country, the Parliamentary forces consisted of 9 regiments of horse, each divided into 6 troops of 80 men, and 14 regiments of foot, 12 of which consisted of 1200 men, and 2 of 1100 men, all exclusive of officers. Each of the regiments was divided into 10 companies; and there were, besides the regiments, 5 bodies each containing 500 men, and 3 others each containing 300 men: these 8 bodies were called companies, and probably they corresponded to the companies or independent bands in the French army before the institution of regiments.

Soon after the Restoration all the regiments were disbanded; two of them, however, one of which is designated the lord-general's regiment of foot, and the other his life-guard of horse, were immediately (1661) re-engaged in the service of the crown; and in the same year the Scotch corps or band of 1700 men, which in the time of James I. had gone into the service of France, returned to England. (Daniel, tom. i., liv. x.) This body was then denominated the First or the Royal Regiment of Infantry: and it boasts of being the oldest regular corps in Europe.

In 1684, or near the end of the reign of Charles II., that part of the English army which was assembled near London was reviewed on Putney Heath; and a list of the officers commanding the several regiments is given by Grose (vol. ii., Appendix No. x.). The first named are three troops of horse-guards, which apparently were the lord-general's life-guards above mentioned. These were afterwards disbanded, and instead of them there were raised two troops of horse-grenadier guards; and in 1788, when the latter were reduced, the two regiments of life-guards at the head of the present list of the British regiments were raised. The second at the review was the Earl of Oxford's royal regiment of horse-guards, which was divided into eight troops; and these are the royal horse-guards which constitute the third regiment in the present list. The third was Lord Churchill's regiment of dragoons, which was divided into six troops, and which is at present denominated the First or the King's Dragoon-Guards.

The infantry consisted of the following corps, namely:—Two battalions of the royal regiment of guards, now called the Grenadier Guards; one battalion of the Coldstream regiment of guards, which regiment still bears that name; one battalion of the Earl of Dumbarton's regiment, or the royal regiment of infantry above mentioned; and one battalion of the Duke of York's, or the admiral's, maritime regiment. This last, which was named in compliment to the king's brother (afterwards James II.), was subsequently disbanded or converted into a regiment of marines. No other regiments were at the review, but there then existed the queen's regiment of foot, since denominated the queen's royal regiment of infantry: the Holland regiment, which was raised in 1665, and was so designated because it had served in that country. This was then considered as the fourth regiment of infantry, after the two regiments of guards, but it was afterwards, and is still, designated the third, in consequence perhaps of the reduction of the admiral's regiment. The same regiment is also called the *Buffs*, from the colour of the facings of the uniforms of the men. In the year 1684 a regiment of infantry was raised in Ireland; and this appears to have been the seventh, but not being considered as in the pay of England till some years afterwards, and other regiments having in the interval been raised, it became the eighteenth on the list. This is now designated the Royal Irish regiment, the epithet royal having been given to it for its gallant behaviour at the siege of Namur in 1695.

The augmentations which have since taken place in the British army consist of one additional regiment of guards (infantry), called the Scots Fusiliers; of 24 additional regiments of cavalry, making, exclusive of the guards, 25 regiments; and of infantry, as many as make 100 regiments of the line, independently of the foot-guards and the Rifle Brigade, the royal regiment of artillery, the corps of royal engineers, and the royal corps of marines. The cavalry then consists of 2 regiments of life-guards, 1 royal horse-guards, 7 regiments of dragoon guards (numbered from 1 to 7), and 18 other regiments of cavalry (numbered from 1 to 18), of which the 1st, 2nd, and 6th are dragoons, the 5th, 9th, 12th, 16th, and 17th are lancers, and the 7th, 8th, 10th, 11th, and 18th are hussars. The infantry consists of 3 regiments of foot-guards, 100 regiments of the line, the rifle brigade, and the following colonial regiments:—3 West India regiments, the Ceylon rifle corps, the Cape mounted rifles, royal Canadian rifle regiment, St. Helena regiment, royal Newfoundland companies, Gold Coast artillery corps, and the royal Malta fencible regiment. To these are now added what were the Honourable East India Company's regiments, which are now amalgamated with the royal army.

As the legions of Henry II. of France bore the names of the several provinces where they were raised, so most of the regiments composing the line of the British army are distinguished by the names of the counties or districts in which the men were enlisted: thus the 3rd is called the East Kent regiment; the 5th, the Northumberland; the 6th, the royal Warwickshire; and so on. The second of the guards, also, is called the Coldstream regiment.

For the divisions and evolutions of a regiment, see Battalion.

REGISTER, REGISTRATION, REGISTRY. In feudal times, the owner of land, or at least the person immediately entitled to the profits arising from it, was usually the occupier, and his right was notorious among his neighbours; for in their presence possession or *seisin* of the land was delivered to him upon the spot by the lord; they signed the instrument, which was evidence of the grant, and they formed part of the lord's court, in which the grant was usually recorded. [Conveyancing.]

But this simple method of conveyance was in the course of time found insufficient for the more complicated circumstances of society. Land by improved cultivation became more productive, and the profits arising from it were devoted to more extensive purposes then when a large proportion of every great estate was waste. Leases of land then became more common, and as the lessee was of course in actual possession of the premises, possession ceased to be sufficient evidence of absolute property in land. Purchasers therefore now require not only proof of possession and production of the instrument by virtue of which the apparent proprietor holds the land, but also an investigation of the *title-deeds*, or documents which form the history of the land; lest any one should hereafter be produced which should be destructive of the claim of the supposed owner, and therefore of the title of those who derive their rights from him. Thus the evidence of a right to land, or to the profits arising from land, consists partly of possession, partly of the *facts* disclosed by the written documents or *title-deeds* relating to it, and hence partly again of the possession of the title-deeds themselves.

But there are many interests in land which exist without either of these protections. For instance, A, who is supposed by all his neighbours to be the owner of an estate which he derives from his ancestors, and has occupied since his father's death, mortgages the land to B for a sum far less than its value: he delivers the title-deeds to B, but (as is usual) retains the possession and entire enjoyment of the land by paying regularly the interest on the mortgage, and being supposed well able to pay the principal money when demanded. A then mortgages the estate a second time to C, to whom he gives notice of the prior incumbrance to B, and thus accounts for the absence of the title-deeds, which C investigates in B's hands. Here we observe that C has an interest in the land, without the security which either possession or the holding of the title-deeds gives. A has the one, B the other. We will suppose the two sums for which the estate is mortgaged to be nearly equal to its value. A borrows a further sum upon it from D, whom he informs of B's mortgage, but not of C's; and in case of dispute the Court of Chancery has to decide between the mortgagees. This would be an easy task if the rule of equity were undeviating, that priority of time gives superior right (qui prior est tempore potior est jure); but the rule that where equities are equal, law shall prevail, destroys the simpler maxim. The two last mortgagees, C and D, have, we may suppose, only an equitable interest in the land, A having granted it at the time of the first mortgage to a trustee for many hundred years, in order that the stipulations of the mortgage-deed shall be fulfilled. [Mortgage.] This is called creating a term of years, and it has the effect of protecting the estate from any acts done subsequently to the creation of the term, and inconsistent with the objects for which it exists. Those terms which have not merged or otherwise ceased are called *outstanding terms*. Now if, in the case supposed, D pays off B, and takes an assignment of his mortgage and of the outstanding term; if, to use the technical phrase, he "tacks" B's security to his own, he unites in himself equal equity with C, and also the legal right which the term gives him; and then he takes precedence of C, who loses the sum which he had advanced, unless indeed he too can find and obtain the assignment of an outstanding term created by one of A's ancestors antecedently to B's. But the case may be more complicated, and the means of fraud still further extended. A dies; and then comes to light a settlement made by his father, to which A was himself a party, which shows that A was entitled to the estate only during his life, that the course in which it should go after his death had been clearly defined, and that it had been conveyed, by his father and himself, to trustees for this purpose. This discovery destroys the estates of B, C, and D alike. These cases, or cases partaking of the character of these, whether the result of ignorance, or accident, or fraud, are frequent sources of litigation: they arise from the facility afforded for the concealment of deeds by the present system of conveying land; and besides the direct injury which they do to the individuals involved in them, they produce a feeling of insecurity concerning the titles to land, which, joined to the difficulty, often the impossibility, of proving titles, especially by descent, renders the alienation of land or the raising of money upon it difficult and costly. Again the advantage derived from obtaining an assignment of outstanding terms causes a conveyancer to investigate the various transfers and transmissions of them with as much care as the title to the fee; and as it may be safest to obtain the assignment of as many outstanding terms as can be procured, and especially of the most ancient, there are a variety of claims to an interest in an estate, all to be proved by the seller, and investigated by the purchaser. The deed too assigning the term is usually distinct from the conveyance of the fee, and is often of great length. Hence vast additional expense is incurred in the sale and mortgaging of land.

But supposing it to be certain that no concealed charge affects land, it may happen that the undoubted owner of it may be unable to prove his right from want of the title-deeds. N possesses an estate, which may be a small part of a much larger estate, of which the owner, M, retains the title-deeds, giving to N authenticated or *attested copies* of them, and a covenant that he, M, (when required, will produce the originals. But M sells the estate, and the title-deeds pass into hands not bound by the *covenant to produce*; or he dies, and his representatives are unknown; or again, N himself sells his portion of the estate, and he cannot transfer the benefit of his covenant [Covenant]; or, by a multitude of accidents, the deeds of some of them are lost. Instances have been known where the mere expense of giving attested copies of deeds, which a person who had contracted to sell an estate was bound to furnish, has exceeded the value of the estate.

A large proportion of the land in the country is thus unmarketable, either from the fear of latent incumbrances, or from the inability of the owner to produce his title-deeds. Prior incumbrances are indeed somewhat assisted by the doctrine of courts of equity, that if a subsequent purchaser or mortgagee has notice of the previous charge before his own transaction with the estate, he shall not by any device obtain priority over that charge. But notice does not necessarily imply knowledge. [Notice.] Notice may be an actual direct intimation of a fact given to the party or his agents, which is called *actual notice*; or it may be only something leading a discreet person to an investigation, which would enable him to discover the fact; thus the existence of a suit (lis pendens) touching the land affects the purchaser or mortgagee with notice. This latter class of notice is called *constructive*; it is so vague as to be easy of proof, and difficult to avoid; and one consequence of the admission of it in a court of equity is, that solicitors often think it their duty to avoid investigations which might lead to constructive notice, and so endanger the priority of their client's security.

These remarks may assist the unprofessional reader in understanding the use of a General Public Register of all deeds or instruments affecting land, in order to secure titles against the loss or destruction, or the fraudulent suppression, or accidental non-production of instruments; to simplify titles by rendering in most cases needless the assignment of outstanding terms; to protect them from the consequences of constructive notice; and to render conveyances shorter and more simple.

To a certain extent such registers have been already established in England. By the 27 Henry VIII., c. 16, it is enacted that all bargains and sales of land shall be enrolled. [BARGAIN AND SALE.] The 2 & 3 Anne, c. 4 (amended by 5 Anne; c. 18) directs that a memorial of all deeds, conveyances, and wills concerning any lands in the West Riding of Yorkshire may, at the election of the parties, be registered; and that any conveyance or will affecting the same lands shall be deemed void against a subsequent conveyance unless a memorial shall be registered. The 6 Anne, c. 35, recites that "lands in the East Riding of York, and in the town and county of the town of Kingston-upon-Hull, are generally freehold, which may be so secretly transferred or conveyed from one person to another, that such as are ill disposed have it in their power to commit frauds, and frequently do so, by means whereof several persons (who, through many years' industry in their trades and employments, and by great frugality, have been enabled to purchase lands, or to lend moneys on land security) have been undone in their purchases and mortgages by prior and secret conveyances and fraudulent incumbrances; and not only themselves, but their whole families thereby utterly ruined;" and then the Act establishes a register of the memorials of deeds and wills in the East Riding of Yorkshire. The 7 Anne, c. 20, establishes such a register for Middlesex; and the 8 George II., c. 6, establishes one for the North Riding of Yorkshire, and provides that deeds, wills, and judgments affecting land may be registered at length, instead of the registration of mere memorials of them. In the Bedford Level too there is a registration of all deeds affecting land there. These registers, owing to the insufficiency of their indexes, and to some other defects, do not answer all the purposes which might be expected from them, and in many respects their arrangements are cumbrous and expensive: nevertheless no one has proposed to abolish them. A registration of wills has long been established, not certainly upon a good plan, since it is not always possible to say beforehand in what court a will has been proved, but nevertheless with great advantage. The Act for Abolishing Fines and Recoveries (3 & 4 Wm. IV., c. 74) substitutes for them a deed which is enrolled in the Court of Chancery. In Ireland, in the Colonies, in most of the United States, in Sweden, France, and Italy, and in many of the German States, registers are established. Nor is it found that the disclosures which a register makes of the state of landholders' property produce inconvenience, even supposing such disclosures inseparable (which they are not) from all systems of registration. It is obviously for the public benefit that the apparent extent of a person's landed property should not induce men to give him a credit to which the actual amount of that property does not entitle him.

It is clear then that if a register is established, which must be sooner or later, it ought to be taken as sufficient notice of the documents registered; and that on the other hand default of registration ought not to be remedied by any proof even of actual notice.

The Act 1 & 2 Vict. c. 110 provides that no judgment of the superior courts, or decree of the courts of equity, shall affect lands unless a memorandum thereof be registered in the Court of Common Pleas. It also enacts that no pending suit (lis pendens) shall affect the purchaser or mortgagee with notice, unless a similar memorandum is registered, this entry also being renewed every five years. The Act also requires crown debtors to be registered in the same office, and provides means for obtaining and recording their discharge from their liabilities to the crown; but the Act does not require the renewal every five years of the entry in this case.

Persons becoming purchasers and mortgagees since the passing of the Act 23 & 24 Vict. c. 38 (23rd July, 1860), are not even affected by this registration of judgments, however, unless process of execution be also issued and registered before the date of the conveyance or mortgage, and enforced within three calendar months after such registration.

REGISTER ACT. [SHIPPING.]

REGISTRATION OF BIRTHS, DEATHS, AND MARRIAGES. Parish registers were not kept in England till after the dissolution of the monasteries. The 12th article of the injunctions issued by Cromwell, Henry VIII.'s secretary, in 1538, directs that every clergyman shall, for every church, keep a book wherein he shall register weekly every marriage, christening, and death; any neglect being made penal. In the first year of the reign of Edward VI. (1547), ecclesiastical visitors were sent through the different dioceses in order to enforce various injunctions, and, among others, that of Cromwell with respect to parish registers. In the beginning of Elizabeth's reign this injunction was repeated, when the clergy were required to make a protestation in which, among other things, they promised to keep the register-book in a proper and regular manner. In 1694 an Act (6 & 7 Wm. III. c. 6) for a general registration of marriages, births, and deaths, was passed merely for purposes of revenue: it is entitled "An Act for granting to his Majesty certain rates and duties upon Marriages, Births, and Burials, and upon bachelors and widowers, for the term of five years, for carrying on the war against France with vigour." It is a very long Act, in which the duties are minutely set down. A supplementary Act was passed (9 Wm. III. c. 32), entitled "An Act for preventing frauds and abuses in the charging, collecting, and paying the duties upon marriages, births, burials, bachelors, and widowers." The 52 Geo. III. c. 146 (28 July, 1812), entitled "An Act for the better regulating and preserving parish and other registers of births, baptisms, marriages, and burials in England," made some alteration in the law, chiefly with reference to having the books made of parchment or strong paper, and to their being kept in dry and well-painted iron chests.

The Registration Act (6 & 7 Wm. IV. c. 86: 17 Aug., 1836), entitled "An Act for registering Births, Deaths, and Marriages, in England," came into operation July 1, 1837. By the 44th section of the 6 & 7 Wm. IV. c. 85, entitled "An Act for Marriages in England," the provisions of this Registration Act are extended to the Marriage Act, and some further facilities and regulations were given by the 19 & 20 Vict. c. 119.

The most important provisions of these Acts are the following:—A general registry-office provided in London at Somerset House. Annual abstract of registers to be laid before parliament. Register-offices to be provided in each union by the guardians, and to be under the care of the superintendent-registrar. Registrar and deputy to dwell in the district, and their names and additions to be put on their dwelling-houses. Register-books to be provided by the registrar-general, for making entries of all births, deaths, and marriages of his majesty's subjects in England, according to prescribed forms. Registrars authorised and required to inform themselves carefully of every birth and death which shall happen within their district, and to learn and register as soon after the event as conveniently may be done, the particulars required to be registered touching every birth or every death. Parents and occupiers, within forty-two days after birth and five after death, to give notice thereof to registrar; and owners and coroners to do so forthwith in cases of foundlings and exposed dead bodies. Parents and occupiers, on being required by the registrar, within forty-two days, to give all the particulars required to be registered respecting birth. Children born at sea to be registered by the captain. After the expiration of forty-two days from the birth of the child, it can only be registered within six months, on the solemn declaration of the particulars before the superintendent-registrar, who is to sign the entry, and to receive 2*s.* 6*d.* and registrar 5*s.*, extra fee; and no registration, after forty-two days, shall be made otherwise than as above, under a penalty of 50*l.* Births are not to be registered after six months, and no registration after that date is to be received as evidence. Name given in baptism may be registered within six months after registration of birth, on production of a certificate by the minister. Some person present at death, or occupier of house, is required to give particulars of death, on application by registrar, within eight days; registrar to make entry of finding of jury upon coroner's inquests. Registry of persons dying at sea, containing particulars, to be kept by the captain. Registrar to give certificate of death to undertaker, who shall deliver the same to the minister or officiating person, and unless such certificate is delivered the minister must give notice to the registrar; but the coroner may order body to be buried, and give certificate thereof; and if any dead body shall be buried without certificate of registry or of inquest, and no notice given to the registrar within seven days, the party forfeits 10*l.* Every register must be signed by the informant. Registrars to make out accounts quarterly, to be verified by the superintendent, and are to be paid by the guardians, as directed. Marriage register books to be provided by the registrar-general for ministers. Marriage registers to be kept in duplicate, and every entry shall be signed by the clergyman, or the registering officer, or secretary of Quakers and Jews, by the persons married, and by two witnesses. Certified copies of registers of births and deaths to be sent quarterly, and the register-books when filled, to the superintendent-registrar. Duplicates and certified copies of registers of marriages to be sent to superintendent-registrar. Superintendent-registrars to send certified copies of registers to the general register-office. Searches may be made and certificates given by the persons keeping the registers, on payment of the fees prescribed. Indexes to be kept at general register-office, searches allowed, and certified copies given. Certified copies (certificate to bear a penny stamp, to be also paid for by the applicant) given at general register-office to be sealed, and shall then be evidence without farther proof. Ministers, &c. may ask parties married the particulars required to be registered; and wilfully giving false information is perjury. The penalty for not duly registering births, deaths, and marriages, or for losing or injuring the registers is not to exceed 50*l.* The penalty for destroying or falsifying register-books, or entries therein, or giving false certificates, is felony. Accidental errors may be corrected, within one month, in the presence of the parties.

Another Act was passed (1 Vict. c. 22—June 30, 1837), entitled "An Act to explain and Amend two Acts passed in the last session of Parliament, for Marriages, and for registering Births, Deaths, and Marriages, in England." This Act consists chiefly of arrangements necessary to extend and improve the provisions of the Registration Act.

Previous to the Registration Act coming into operation it was necessary to divide the country into districts of convenient size for equalizing the labours of the registrars by contracting the area where the population was dense, and extending it where the population was thin. To each district a registrar of births and deaths is appointed, and also a registrar of marriages; and in each union there is a superintendent-registrar. The registrar of births and deaths is appointed by the guardians, and is always a resident in the district in which he acts. The registrar of marriages is appointed by the superintendent-registrar, subject to the approval of the guardians.

On August 7, 1854, an Act for assimilating the registration of births, deaths, and marriages in Scotland to that of England was passed. A registrar-general was appointed, and the returns of the two kingdoms are now annually laid before parliament. The measure has not yet been applied to Ireland.

REGISTRATION. (*Scotland.*) The registration of documents in Scotland is intimately connected with the titles of real property, and with the execution of the law. It is thus divided into two distinct departments, which may be considered separately—Registration for Preservation and Registration for Execution.

Registration for Preservation, in its simplest form, is merely the preserving of an attested transcript of any deed in a public register, that thus an authentic copy may be had recourse to in case the original should be lost. Besides the regular statutory records of particular deeds, there are books attached to the several courts of civil jurisdiction, in which parties may for their own convenience register such documents as do not require by any special obligatory law to be recorded. It is a general rule that extracts from any such records may stand in the place of the originals when these are not forthcoming. In the case of deeds, of which, as will be seen below, it is not the deed itself, but its registration, that makes the completed title, an extract from the register is the proper document to be produced. In actions, however, the object of which is the annulling the deed on some legal ground, the original must be produced if it be accessible. It is usual to speak of registration for preservation as being also for publication; and in this sense, when a deed is of such a character that to make it effectual in the grantee's favour it must have been delivered to him by the grantor, such registration is in the general case equivalent to delivery. It will operate in this respect in adjusting questions of competing right, as where a father makes over to one child the property that, in case of his dying intestate, would go to another, and registers the deed. The registration of ordinary documents for preservation was sanctioned by the Act 1698, c. 4, which generally extends to registration "in any authentic public register that is competent." Besides the central register attached to the supreme court, there are others connected with the Sheriff and Corporation Courts; but it does not appear to be distinctly settled what may be, with reference to various descriptions of documents in each case, a "competent" register.

The most important of the registers for preservation is that of the "Sasines *and* Reversions," the former word expressing the act by which an estate is created or transferred in heritable (that is, real) property, the latter the attestation of the extinction of a burden (that is, of the devolution of a temporary estate on the person entitled to the remainder). This system has been gradually formed. In its present state its main operative principle is, that when a title to land appears on the register, no latent title derived from the same authority can compete with it, and that registered titles rank according to their priority; so that if A first sell his property to B and execute the proper conveyance, and subsequently sell the same property to C, if C get this title first recorded it cannot be questioned by B, who has only his pecuniary recourse against A. In pursuance of this system, in transactions regarding land, the public records are relied on as affording the means of ascertaining the character and title, and after they have searched for the period of prescription, or examined over a period of forty years [Prescription], parties can trust that there are no latent rights, and may safely deal with the person who professes to dispose of any right connected with it. The origin of this system may be traced to the commencement of the 16th century, when the notaries were required to record their proceedings in their protocols, and the other officers connected with the feudal transference of land were bound to make returns of their official acts. In 1599 an Act was passed in which an effort was made to produce regularity in these registers, by penalties. It was by the Act 1617, c. 16, that the system was founded on its right principle. The preamble of that statute bears "considering the great hurt sustained by his Majesty's lieges by the fraudulent dealing of parties who having annallied [alienated] their lands, and received great summes of money therefore, yet by their unjust concealing of some private right formerly made by them, render the subsequent alienation done for great summes of money altogether unprofitable; which cannot be avoided unless the said private rights be made public and patent to her Majesty's lieges." The Act then appoints the deeds to be registered, otherwise they are "to make no faith in judgment, by way of action or exception, in prejudice of a third party, who hath acquired a perfect and lawful right to the said lands and heritages: But (without) prejudice alwayes to them to use the said writs against the party maker thereof, his heirs, and successors." There was a material defect in this Act, that a person might have his title immediately registered, but was liable to have it superseded by any other person able to register a title on a warrant previously obtained. This was remedied by the Act 1693, c. 13, which gave the registerable titles priority not according to the date of their execution, but to that of their registration.

When property is offered for sale or mortgage, a "search" generally forms part of the titles offered for inspection to the parties treating for it. This is a certificate by the proper officer, describing all registered documents regarding that particular piece of land which have been recorded during forty years. It is remarkable that the enlightened mind of Cromwell appears to have comprehended the utility of this system, and that he made an effort to introduce it into England. We are told by Ludlow (Memoirs, I., p. 436), "In the meantime the reformation of the law went on but slowly, it being the interest of the lawyers to preserve the lives, liberties, and estates of the whole nation in their own hands, so that upon the debate of registering deeds in each county, for want of which, within a certain time fixed after the sales, such sales should be void, and being so registered that land should not be subject to any incumbrance, this word incumbrance was so managed by the lawyers that it took up three months' time before it could be ascertained by the committee."

Registration for Execution is another peculiarity of the law of Scotland, although the system of warrants to confess judgment in England in some measure resembles it. The party to a solemn deed incorporates with it a clause of registration, by which, on the deed being registered in the books of a court competent to put the deed in force, the decision of the court shall be held as pronounced in terms of the deed, and execution may proceed against the party on an extract, as if it were the decree of a court. The engagement on which such execution may issue must be very distinctly set forth. Thus, if it be for payment of money, it must be for a sum named in the deed, and not for the balance that may be due on an account arising out of the transactions to which the deed refers. This method of execution was by statute (1681, c. 20) made applicable to bills and promissory notes without their containing any clause of registration. To entitle it to this privilege, the bill or note must be apparently without flaw, must bear the appearance of due negotiation, and must have been protested. The operation of this system was much widened by the Act 1 & 2 Vict. c. 114, which extended registration for execution to the Sheriff Courts.

REGISTRY OF SHIPS. [Ships.]

REGIUS MORBUS, as used by the classical Latin authors, must not be confounded with the *King's evil*, or *Regius morbus*, of the writers of the middle ages. In the former it means jaundice (Horat., 'Art. Poet.,' 453), called also *ἴκτερος*, "morbus arquatus," and "aurugo" (or "aurigo"); in the latter it means scrofula. [Scrofula.] The derivation of the term as applied to jaundice is both uncertain and unsatisfactory. According to Serenus Samonicus ('De Medic.,' cap. 58, v. 1033)—

> "*Regius* est vero signatus nomine morbus,
> Molliter hic quoniam celsa curatur in aula."

Varro (apud Plin., 'Hist. Nat.,' lib. xxii., cap. 53, ed. Tauchn.), "*Regium* cognominatum morbum arquatum tradit, quoniam mulso curatur;" "Scilicet" (says Doering, ad Horat., *loc. cit.*), "*mulsum* (vinum melle conditum) pertinet ad delicias, quas reges imprimis et beatiores appetunt et facile sibi comparare possunt." The same derivation is given by Celsus ('De Medic.,' lib. iii., cap. 24), who says the cure is to be attempted by various kinds of exercises: "Lecto etiam et conclavi cultiore, lusu, joco, ludis, lascivia, per quæ mens exhilaretur, ob quæ *regius* morbus dictus videtur." Blancardus (*Blanckaert*, or *Blankaard*) in his 'Lexicon Medicum,' is rather inclined, "ab *auro*, metallorum *rege*, denominationem statuere, sicut et *Aurigo*, ab *auri* colore." Dr. Good ('Study of Medicine') says, "the meaning of *Regius*, as expounded by Celsus, will, I apprehend, content very few;" he then remarks that this and the two other Latin names of the disease (*Arquatus Morbus* and *Aurugo*) "are not indeed univocals, but very clearly equivalents, and equally import *gold*, *golden crown*, *golden bow*, or *circumfusion*; the colour of the disease, and its encompassing the body." Each of these derivations appears somewhat far-fetched and unsatisfactory, and the term is probably one of those of which no plausible explanation can be given.

REGRATING. A regrator is defined (6 Ed. VI., c. 14) to be one who buys in a fair or market the various articles specified by the Act, which are principally articles of provision, and sells them again in the same or in any other fair or market within four miles. That statute and others providing certain penalties for such acts have all been repealed by 12 Geo. III., c. 7.

REGULAR CLERGY [Clergy.]

REGULAR FIGURES, POLYGONS, SOLIDS, POLYHEDRONS. We have here to add to what is said in Polygon and Polyhedron all that concerns the regular figures or solids, not as to their general properties, but as to the proportions of their parts and the mode of describing them. We shall take first the plane figures, and then the solids.

A regular polygon, meaning one of which all the sides are equal and all the angles are equal, may have any number of sides from three upwards. The Greek terms trigon, tetragon, pentagon, hexagon, heptagon, octagon, nonagon, decagon, undecagon, dodecagon, are in use (except the first two) to express polygons of three, four, &c., up to twelve sides. The term quindecagon is in use to express the polygon of fifteen sides.

Let the polygon be described, having n sides: let its side be a, its area V, and let r and R be the radii of the inscribed and circumscribed circles. The formulæ which connect these quantities are then as follows:—Let v stand for the nth part of 180°, then

$$a = 2\,\text{R}\sin v = 2r\tan v,$$

$$\text{V} = \frac{na^2\cot v}{4}$$

which are enough to determine the remaining three of V, a, R, r, when one of them is given. To facilitate the determination and construction of any regular polygon not having more than 12 sides, we take the following table from James Dodson's 'Calculator' (1747), which is correct to every figure so far as we have thought it necessary to examine it. The author generally corrected errata with his own pen in every copy, and the one before us has his corrections:—

When the Length of Side = 1.

No. of Sides.	Radius of Circumscribed.	Radius of Inscribed.	Area.
3	0·5773503	0·2886751	0·4330127
4	0·7071068	0·5000000	1·0000000
5	0·8506508	0·6881910	1·7204774
6	1·0000000	0·8660254	2·5980762
7	1·1523825	1·0382617	3·6339124
8	1·3065630	1·2071068	4·8284271
9	1·4619022	1·3737387	6·1818242
10	1·6180340	1·5388418	7·6942088
11	1·7747329	1·7028437	9·3656404
12	1·9318516	1·8660254	11·1961524

When Radius of Circumscribed Circle = 1.

No. of Sides.	Length of Side.	Radius of Inscribed.	Area.
3	1·7320508	0·5000000	1·2990381
4	1·4142136	0·7071068	2·0000000
5	1·1755705	0·8090170	2·3776412
6	1·0000000	0·8660254	2·5980762
7	0·8677674	0·9009689	2·7364102
8	0·7653668	0·9238795	2·8284271
9	0·6840403	0·9396926	2·8925437
10	0·6180340	0·9510565	2·9389263
11	0·5634651	0·9594931	2·9735250
12	0·5176381	0·9659259	3·0000000

When Radius of Inscribed Circle = 1.

No. of Sides.	Length of Side.	Radius of Circumscribed.	Area.
3	3·4641016	2·0000000	5·1961524
4	2·0000000	1·4142136	4·0000000
5	1·4530851	1·2360680	3·6327128
6	1·1547005	1·1547005	3·4641016
7	0·9631491	1·1099160	3·3710222
8	0·8284271	1·0823919	3·3137084
9	0·7279405	1·0641776	3·2757315
10	0·6498394	1·0514622	3·2491970
11	0·5872521	1·0422172	3·2298913
12	0·5358984	1·0352760	3·2153904

When Area = 1.

No. of Sides.	Length of Side.	Radius of Circumscribed.	Radius of Inscribed.
3	1·5196716	0·8773827	0·4386912
4	1·0000000	0·7071068	0·5000000
5	0·7623870	0·6485251	0·5246678
6	0·6204033	0·6204033	0·5372849
7	0·5245813	0·6045183	0·5446520
8	0·4550899	0·5946034	[illegible]·5493420
9	0·4201996	0·5879764	0·5525172
10	0·3605106	0·5833184	0·5547687
11	0·3267617	0·5799148	0·5564242
12	0·2988585	0·5773503	0·5576775

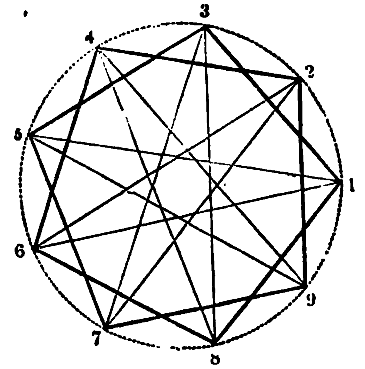
By means of these tables the construction of any figure is immediately reduced to a short calculation, the drawing of a circle, and setting off equal chords on that circle, the compasses and a scale of equal parts being all the instrumental aid necessary. It is required to construct, for example, a regular heptagon, or figure of seven sides, with an area of 225 times the square on one of the larger divisions of the scale. The side and radii must therefore be increased in the fourth table in the proportion of $\sqrt{225}$ to $\sqrt{1}$, or of 15 to 1. And

·5245813 × 15 = 7·8687 side.
·6045183 × 15 = 9·0678 rad. circum.
·5446520 × 15 = 8·1698 rad. inscr.

If the two circles be carefully drawn from the same centre, and chords equal to the side taken off, the compasses will be found to be carried exactly seven times upon the larger circle, and the chords, being drawn, will be found to touch the inner circle, and any little error of construction will be better shown by failure of touching the inner circle correctly than by any other means.

The above presumes that it is desired to proceed as accurately as possible; but for rough work, and when the circumscribed circle is known, the proportional compasses, or even a common pair of compasses and trial, will succeed perfectly well. The proportional compasses have a scale for the adjustment of the pivot in such manner that when the opening at one end is the radius of a circle, that at the other end shall be the side of the inscribed polygon of a given number of sides.

The regular polygons hitherto treated have been those of Euclid, without any re-entering angles. The star-shaped polygons (which, though equilateral and equiangular, do not come within Euclid's definition) are described by drawing a regular polygon of the same number of sides, and drawing successive diagonals so as to cut off a number of sides which is prime to the number of sides of the polygon.



Thus, if 12, 23, 34, &c., be the sides of a regular nonagon, or nine-sided polygon, it follows that there are two regular star-shaped nonagons, one made by diagonals which cut off 2 or 7 sides, and one made by diagonals cutting off 4 or 5 sides. Diagonals cutting off three sides would give three equilateral triangles, but no nonagon at all. These nonagons are 1357924681, and 1594837261. Star-shaped dodecagons are also only one in number, since 5 and 7 are (except 1 and 11, which would only give the dodecagon of Euclid) the only numbers less than 12 which are prime to 12. But a regular polygon of 13 sides has 5 star-shaped polygons, made by diagonals cutting off 2 and 11, or 3 and 10, or 4 and 9, or 5 and 8, or 6 and 7 sides.

We now come to the subject of regular polyhedrons, presuming the reader to know the contents of the article POLYGON AND POLYHEDRON. A great many properties of these solids have been investigated, but as they are of little use, it will be unnecessary to do more than give tables for constructing them of given dimensions. Let a solid be contained by f faces, each of which is a regular polygon of n sides. Let c be the number of corners or solid angles, e the number of edges, and m the number of angles which meet at a corner. Then since there are c corners with m angles at each, the number of edges, counting each edge as often as it meets a corner, is mc; or, as each edge meets a corner twice, $\frac{1}{2}mc=e$, the number of distinct edges. Again, since there are f faces, of n sides each, and every edge is the union of two faces, we have $\frac{1}{2}nf=c$. But $f + c = e + 2$, or

$$\frac{2e}{n}+\frac{2e}{m}=e+2, \text{ or } e=\frac{2mn}{2m+2n-mn}$$

which must be a whole number. And neither m nor n can be less than 3, nor greater than 5, for there are no figures of fewer sides than 3, and [POLYGON AND POLYHEDRON] spaces cannot be inclosed entirely by figures of more than five sides. The rest follows from the properties of conjugate solids in the same article.

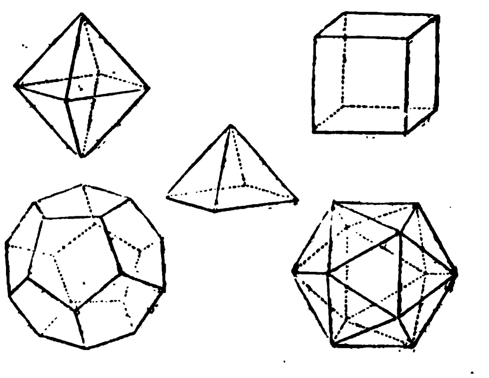
Let $n=3$, or $e=6m\div(6-m)$. This is a whole number (1) when $m=2$; this must be rejected: (2) when $m=3$, giving $n=3, m=3, e=6$,

$f=4$, $c=4$, or four triangles; we have here the regular tetrahedron, or triangular pyramid: (3) when $m=4$, giving $n=3$, $m=4$, $e=12$, $f=8$, $c=6$, or eight triangles; we have here the regular octohedron: (4) when $m=5$, giving $n=3$, $m=5$, $e=30$, $f=20$, $c=12$, or 20 triangles; we have here the regular icosahedron.

Let $n=4$, or $e=8m\div(8-2m)$. This is a whole number (1) when $m=2$; which reject: (2) when $m=3$, giving $n=4$, $m=3$, $e=12$, $f=6$, $c=8$, or six squares; we have here the regular hexahedron, or cube, the only one of its kind.

Let $n=5$, or $e=10m\div(10-3m)$. This is a whole number (1) when $m=2$; which reject: (2) when $m=3$, giving $n=5$, $m=3$, $e=30$, $f=12$, $c=20$, or 12 pentagons; we have here the regular dodecahedron, the only one of its kind.

We have thus the five regular solids, and have shown that there can be no others.



The centre of a regular polyhedron is obviously the point of intersection of lines drawn from the corners, each inclined at the same angle to all the edges which meet it. The radius of the circumscribed sphere is the line drawn from any corner to the centre; that of the inscribed sphere is the perpendicular let fall from the centre upon any of the faces.

The following table answers to that for polygons, and is taken from the same source:—

When the Side = 1.

Solid.	Radius Circumscribed.	Radius Inscribed.	Superficies.	Volume.
Tetrahedron . .	0·6123724	0·2041241	1·7320508	0·1178511
Hexahedron . .	0·8660254	0·5000000	6·0000000	1·0000000
Octohedron . .	0·7071068	0·4082483	3·4641016	0·4714045
Dodecahedron . .	1·4012585	1·1135164	20·6457280	7·6631188
Icosahedron . .	0·9510565	0·7557613	8·6602540	2·1816951

When Radius of Circumscribed Sphere = 1.

Solid.	Side.	Radius Inscribed.	Superficies.	Volume.
Tetrahedron . .	1·6329932	0·3333333	4·6188023	0·5132002
Hexahedron . .	1·1547005	0·5773503	8·0000000	1·5396006
Octohedron . .	1·4142136	0·5773503	6·9282032	1·3333333
Dodecahedron . .	0·7136442	0·7946545	10·5146228	2·7851639
Icosahedron . .	1·0514622	0·7946545	9·5745413	2·5361567

When Radius of Inscribed Sphere = 1.

Solid.	Side.	Radius Circumscribed.	Superficies.	Volume.
Tetrahedron . .	4·8989795	3·0000000	41·5692193	13·8564064
Hexahedron . .	2·0000000	1·7320508	24·0000000	8·0000000
Octohedron . .	2·4494897	1·7320508	20·7846096	6·9282032
Dodecahedron . .	0·8980560	1·2584086	16·6508731	5·5502910
Icosahedron . .	1·3231691	1·2584086	15·1621684	5·0540561

When the Superficies = 1.

Solid.	Side.	Radius Circumscribed.	Radius. Inscribed.	Volume.
Tetrahedron . .	0·7598357	0·4653025	0·1551008	0·0517003
Hexahedron . .	0·4082483	0·3535534	0·2041241	0·0680413
Octohedron . .	0·5372850	0·3799178	0·2193457	0·0731152
Dodecahedron . .	0·2200822	0·3083920	0·2450651	0·0816884
Icosahedron . .	0·3398080	0·3231774	0·2568144	0·0856048

When the Volume = 1.

Solid.	Side.	Radius Circumscribed.	Radius Inscribed.	Superficies.
Tetrahedron . .	2·0395489	1·1547006	0·4163417	7·2056240
Hexahedron . .	1·0000000	0·8660254	0·5000000	6·0000000
Octohedron . .	1·2848990	0·9080604	0·5245576	5·7191069
Dodecahedron . .	0·5072221	0·7107492	0·5648000	5·3116140
Icosahedron . .	0·7710254	0·7332887	0·5827111	5·1483486

REGULAR POLYGON, REGULAR SOLIDS. [REGULAR FIGURES.]

REGULATORS OF MOTION. Fly-wheels are the means usually employed to render the movements of machines as nearly as possible uniform; and the nature as well as the applications of these will be described under WHEELS, and under STEAM-ENGINE. Pendulums, as regulators of motion for clock-work, are described under PENDULUM; and the *Governor*, by which the supply of steam is regulated, will be described under STEAM-ENGINE. Some account of air-vessels for regulating motion in the tread-wheels, which are employed in prisons, has been given under AIR-VESSEL, and it may be added that a particular kind of fly has been occasionally used for the like purpose. This consists of a vertical rod or shaft about 20 feet high, carrying at its upper extremity, on opposite sides, a long rectangular frame, which is provided with shutters turning on hinges; by the revolution of the shaft these frames turn round horizontally; and the shutters being connected with two governor-balls by means of wheel-work, when the motion of the tread-wheel becomes too rapid, the diverging balls cause the shutters to close, and thus the resistance of the air diminishes the velocity. Should the movement of the tread-wheel become too slow, the balls collapsing allow the shutters to open, when the resistance of the air is diminished and the velocity of revolution increases.

RE'GULUS. A line drawn from the pole-star, not through the two pointers, but between them and the five secondary stars of the Great Bear, which lie near them, will pass through the bright star called *α* Leonis, or Cor Leonis (the lion's heart). By Ptolemy and other Greeks it was called *βασιλίσκος*, whence comes the Latin name Regulus, a word which is the diminutive of *rex*.

REINSCH'S TEST FOR ARSENIC. [ARSENIC, DETECTION OF.]

REJOINDER. [PLEADING.]

RELAPSING FEVER. [BLOOD, DISEASES OF THE.]

RELATION (Mathematics). What we here mean by this word would have been explained in the article EQUATION, if we had confined ourselves to the explanation of arithmetical algebra; but having in the articles ALGEBRA and OPERATION endeavoured to give higher views, we are induced to insert the present article by remembering that the difficulties of such a subject are of very different kinds to different persons, insomuch that any point of view may be usefully taken with reference to some minds, and any detail upon a fundamental notion may remove misapprehension in one quarter or another.

All reasoning is the discovery of relations which are not evident from those which are; or rather, since the proposed result is sometimes evident in itself, reasoning is the establishment of one relation as a necessary consequence of others. The term relation would be difficult to define in a manner satisfactory to all; it is enough for our present purpose to say a relation exists between any two objects, whether of sense or intellect, whenever they have anything in common; that is to say, the common point, whatever it may be, may be made the means of referring one to the other, or bringing our thoughts from one to the other, so as to think of both at the same time, and to compare the two. All the manifold senses of the word may be derived from this one: the relationship of blood implies a common ancestry; the relationship of office, common duties. In mathematics, the relation of greater, equal, or less, implies that one of the magnitudes is the same as to quantity with part or all of the other, and so on. Sameness in every respect would constitute identity; sameness in one or more respects, relation. The triangles in Euclid, i. 4, are by hypothesis related in a given manner in three particulars: a change of place shows that they can be made identical; that is, their difference before the change of place was difference of position only, not at all of form; in all that can distinguish one triangle from another, except its position in space, they are identical. We do not quarrel with the phrase that they are the same triangles differently placed, because sameness is understood with a reservation, and the preceding means that they are the same except in difference of place.

In an algebraical expression we may have to consider its meaning, form, magnitude, source, mode of derivation, and properties. The meaning depends upon the fundamental definitions which are employed and the form; the form, upon the arrangement of the symbols; the magnitude, when magnitude is signified, upon the form and the particular values given to the symbols; so that these various sources of relation are closely connected with one another. The fundamental meaning of the sign = implies equality of quantity or magnitude, and some insist that it shall always retain this meaning. There can be no objection to any one insisting on this point for himself; but the learner—who, if he be wise, will learn all languages with the majority, even though he should afterwards teach with the minority—must make himself accustomed to various uses of this sign, as follows:—

1. The sign = means that on one side we have an operation to be

performed, and on the other side the result of performing that operation by general rules, as in

$$(x+a)\,(x-a)=x^2-a^2 \qquad a^7\div a^7=a^0.$$

Whenever the resulting form is intelligible both in form and magnitude, the resulting relation is equality of magnitude under difference of form, independently of the particular values of the symbols; but when the result is unintelligible, as is the second of the preceding results when first obtained, this relation no longer exists: the process described in INTERPRETATION makes it exist. In all such cases the relation is that of sameness of value and properties, sameness in fact of everything but form; and the relation is independent of the magnitude of the algebraical symbols.

But did no relation exist in $a^7\div a^7=a^0$, until we had interpreted the then unknown symbol a^0 to mean unity? We answer, that a relation did exist—namely, sameness of properties. The value of the first side is unity; the unknown symbol of the second side would be found on trial to have all the properties of the unit, when common algebraical rules are applied. If we were to refuse the interpretation, and consider a^0 as a self-contradictory symbol, we could not deprive it of the properties of a unit, or rather, we could not deprive ourselves of the knowledge that the algebraical use of it would produce the same results as the algebraical use of a unit.

To the same head may be referred the meaning of =, as connecting an infinite series with its finite source of development (or its invelopment). Arithmetical equality may not exist, for the series may be divergent; but between the development and its invelopment exists the relation of sameness of properties, and the relation of sameness of source. The infinite series $1-1+1-1+$, &c., is equated to half a unit; that is, the sign = is put between $\frac{1}{2}$ and $1-1+1-1+$, &c., *ad inf.* The relation of sameness of magnitude has no existence, for $1-1+1-$, &c., *ad infinitum*, furnishes no definite idea of magnitude; but in properties, the two are the same.

2. The sign = means the relation of sameness of magnitude, without reference to form; and in this sense its use generally imposes conditions on one or more of the symbols employed, and always does so unless when the sign might also truly have the meaning described under the first head. Thus $2x+3=x+4+x-1$ imposes no condition on the value of x, because the first side is only a more simple performance of the operations indicated on the second side; but $2x+3=21-x$ is the assertion of a relation existing which is not true of the forms, and is not generally true as to the magnitudes. The condition $x=6$ is necessary to the truth of the relation asserted to exist. Relations of this sort, under the name of equations, are the first which meet the student at his entrance into algebra; and he frequently has a subsequent difficulty in extending the use of the symbol =. Being accustomed to see it impose conditions of magnitude, he cannot easily cease to imagine that it always does so; and he looks upon the two equations

$$\epsilon^x=1+x+\frac{x^2}{2}+\text{\&c.}, \qquad \text{and } x+1=2,$$

as things of the same kind, differing only in complexity. To prevent this, the distinction between *identical* equations (so called),—namely, assertions of the relation described under the first head,—and equations *of condition*, should be strongly marked at the outset of his course. It would even be wise to use somewhat different symbols for the two relations: thus ══════ might denote the first described relation, and = the second. The learner might drop the slight distinction which exists between the two symbols when he finds himself able to do without it; but we are satisfied that those who had once learned to use it would never think the time was come when they might safely drop it.

3. The sign = means the relation of algebraical identity between the results of different operations, when the symbols are not symbols of magnitude, but of OPERATION: that is, it asserts the relation of sameness of effect between the two operations which are written on one side and the other of it. And here it is in truth used in the first sense described, the difference being in the meaning of the symbols, not in that of the relation. And here again there is the distinction between the case in which the relation is explicable from definitions, and that in which it requires interpretation. Thus, in the relation $(1+\Delta)^2=1+2\Delta+\Delta^2$, we can prove and verify that the operation $1+\Delta$ is of that sort which, if performed twice following, will yield the same result as the sum of the results of the operations 1, 2Δ, and Δ^2. But when, having established, as in the article cited, a right to the use of all the ordinary transformations of algebra, we come to $1+\Delta=E^D$ and $D=\log\,(1+\Delta)$, we have results of which the first side only is explicable, and the second requires interpretation. It might be satisfactory to consider such symbols as $\log\,(1+\Delta)$, &c., in no other light than as abbreviations of the series into which they might be developed in common algebra; but as such a use of interpretation seems to a beginner to be more arbitrary than it really is, we may point out how to make the passage in a somewhat more guarded manner, presuming the reader to be perfectly well acquainted with the results of the article OPERATION.

If A, B, &c., stand for symbols of operation, then $A\pm B$, AB, $A\div B$, are compound results of operation, which are capable of and actually receive a distinct definition. Similarly, A^n is also deducible in meaning from the definition when n is any number, whole or fractional, positive or negative; but A^B, where B is also a symbol of operation, cannot be immediately explained from definition. But it is to be remembered that an algebraic quantity may be susceptible of different definitions, though really amounting to the same definition. Sometimes nothing more than a mere change of the form of words will render a notion capable of being rationally extended further than it could have been before the change was made. For instance, in FRACTIONS, we understand the division of 7 into 3 equal parts, and into 4 equal parts; but a division into $3\frac{1}{2}$ equal parts is a set of words without meaning. But if we only speak of taking parts of which three make 7, and other parts of which four make 7, it is perfectly easy to imagine parts such that three parts and half a part make 7. Can we not, then, take such a method of defining A^B as, without in any way altering its common meaning, shall present that common meaning in a form which will be intelligible when A and B are symbols of operation?

In BINOMIAL THEOREM it is proved that the equation $\phi x\times\phi z=\phi\,(x+z)$ can only be satisfied for all values of x and z, by $\phi x=c^x$ where c is independent of x.

If, then, we propose the equation—

$$\phi x\times\phi z=\phi(x+z) \quad , \quad \ldots\ldots (1)$$

the only solution must be c^x. It is easy enough to show that—

$$c^x\,.\,c^z=c^{x+z};$$

the proof referred to shows that c^x is the *only* solution of this equation. If z and x be symbols of operation, and if by ϕx we mean a combination of operations performed with x, and by $\phi x\,.\,\phi z$ the result of successively performing the operations ϕz and ϕx, we may denote by y^x an operation which is such, that calling it ϕx, the successive performance of ϕx and ϕz is equivalent to that of $\phi(x+z)$; and that, calling it ψy, the successive performance of ψy and ψz is equivalent to that of $\psi(yz)$. If we want to define the particular operation A^x, we must add to the equation (1) the following:—

$$\phi(1)=A.$$

Thus, let it be the definition of ϵ^D, D being a symbol of operation, that we have here an operation such that if it and $\epsilon^{D'}$ were successively performed, the result would be the same as if $\epsilon^{D+D'}$ were performed at once; this last symbol implying that the operation $D+D'$ is used in the same way as D in the first. Moreover, let it be understood that if D were 1—that is, if the operation D produced no alteration in the function operated on—the result of ϵ^D would be simple multiplication by ϵ. There is nothing in this definition which is unintelligible, though there is something unknown. An operation is defined by means of itself; the definition must then be developed before its object can be understood, but it is not the less a definition—that is, a description of some one operation, and a distinction between it and every other. Thus, in common algebra, the magnitude of x may be defined by an equation, say $x=12-x$. Here x is only given in terms of its unknown self, but it is not the less defined to be 6, and nothing but 6. When the step above described has been made, it is (owing to the demonstrated connection of the rules of common algebra with those of the calculus of operations) the same process to prove that—

$$\epsilon^D=1+D+\frac{D^2}{1\,.\,2}+\ldots.$$

when D signifies an operation, as when it signifies a quantity.

The definition of log D is that this operation is the inverse of ϵ^D with respect to D; so that log ϵ^D means D. Those functions which in common algebra are trigonometrical [SINE] cannot be defined in the subject of which we are speaking otherwise than by reference to the well-known exponential forms. Thus, D denoting an operation—

$$\text{Cos D means } \frac{1}{2}\left\{\epsilon^{D\sqrt{(-1)}}+\epsilon^{-D\sqrt{(-1)}}\right\}$$

$$\text{Sin D means } \frac{1}{2\sqrt{(-1)}}\left\{\epsilon^{D\sqrt{(-1)}}-\epsilon^{-D\sqrt{(1-)}}\right\}$$

It might perhaps be said that though we have constantly used the word relation, yet we have considered nothing but identity, that is, either identity of magnitude, form, process, or properties; but that the term in common life refers to something short of complete identity, frequently meaning mere connection, and sometimes only analogy, or even nothing more than resemblance. We answer, that relation always refers to identity of some sort. For example, there is a relation between the position of the sun and moon and the state of the ocean. Here the word means merely a connection; but this connection involves an absolute identity: having given the position of those heavenly bodies with respect to any place, together with the direction and quantity of their motions, the height of the water at that place is connected with the quantities which express those positions and motions by an equation or a mathematical identity. Resemblance again means identity in some respect, or near approach to identity: analogy, a term generally applied to relations of similarity, will be found to admit of the word sameness being used instead of similarity. Thus, when we say that substance is formed from *substare* in a manner similar to that in which distance is formed from *distare*, the analogy asserted is one of absolute identity (of mode of derivation).

Reasoning by analogy is either the same thing as common reasoning; or else analogy is but another word for induction. If A give B, and C have something in common with A, it may be a necessary consequence that C gives D; D being connected with C in the same manner as B with A. But this happens only when the following of B from A is a necessary consequence of that which A and C have in common, and of that only: in which case the deduction of D from C by analogy with the deduction of B from A, is only an assertion of the possibility of applying the same mode of proof to that part or property of C which was previously applied to the same part or property of A. But when we conclude by analogy of a horned animal that it is not carnivorous, as it is said; that is, when we conclude that the horned animal of which we speak will resemble all other horned animals which we know, in every point in which they resemble each other, we apply no other process than the establishment of a highly probable result by induction.

Reasoning by pure analogy, is then, not absolutely demonstrative reasoning, except in the case above described, in which we want no new name for the process. But attention to analogy in the structure of definitions, and in the route of investigation, is necessary to the success of many inquiries, and gives clearness and saves time in all. Indeed it may be taken as a maxim that whenever there is any species of resemblance pervading the results of two branches of inquiry, there ought to be a reason for that resemblance in the nature of the two subjects, expressed by a resemblance of the notations used; and this reason ought to be made prominent and insisted on.

For instance, we have two distinct *algebras* [Algebra], which, for temporary distinction, we may call arithmetical and geometrical, using the same symbols in the same manner, but proceeding upon meanings given to those symbols which appear altogether different. The only reason given to the student in the article cited, to justify the definitions of the latter, or geometrical algebra, was that they would be found to answer a certain purpose, namely, to make all theorems in the earlier algebra true, when no other alteration was made than that of the meanings of the symbols. It is now to be asked, why have the new definitions that property? what relation have they to the old ones which gives the results of the two a perfect community of form? The answer to this question is not very difficult; but it will require us first to consider what are the operations of common arithmetic, and how they are to be described in terms of the simplest notions of the science.

The fundamental operations of arithmetic are addition, subtraction, multiplication, and division. Of these we may make the definitions of subtraction and division follow from those of addition and multiplication: thus subtraction is the process which destroys the effect of addition, and division that which destroys the effect of multiplication.

The fundamental ideas of arithmetic are, first, that absence of all magnitude which must precede the consideration of any particular number; secondly, the particular magnitude which we choose for repetition, and to which we refer other magnitudes. Nothing and unity are the names of these ideas; and 0 and 1 are their well-known symbols. The first, 0, reminds him who uses it, of the state in which he is antecedently to thinking of any number; the second, 1, of the successive accessions by which he passes from one object of consideration to another. If 0 do not present itself before we can think of any number, it is that we avoid it by an act of memory; but if, for instance, a person had forgotten what seven was, as a young child might do in learning arithmetic, he would be obliged, beginning from 0, to construct 7 by repeated accessions of a unit each time.

Now addition of one number to another is a process which merely puts a number in the place of *nothing*, and proceeds to count from that number in the same manner as when we form the number to be added from 0. Thus to add b to a we do with a what we should have done with 0 to form b: to add 4 to 3, we do with 3 what we should have done with 0 to form 4. If this last operation were performed on the fingers, we should first complete three, and then count the fingers which make four from and after the completion of the three; thus—

$$4=0+1+1+1+1$$
$$3+4=3+1+1+1+1$$

This definition of addition, namely, that "$a+b$ is a direction to do that with a, which would give b if a were nothing," will now be put by for a moment, until we are ready to apply it in the construction of the new algebra.

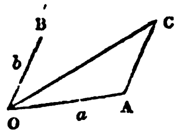
Multiplication of one number by another is a process which puts a number in the place of *unity*, and proceeds to use that number in the same manner as we use unity when we make another number. Thus, to multiply a by b, we do with a what we should have done with unity to make b; to multiply 3 by 4, we do with 3 what we should have done with unity to make 4. Thus,

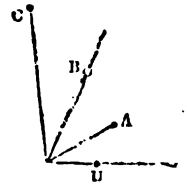
$$4=1+1+1+1,$$
$$3\times 4=3+3+3+3.$$

The definitions of subtraction and division are then obtained, as before described, by the supposition of inverse operations, or operations destructive of the effects of addition and multiplication.

In consequence of the preceding considerations, we shall pass from the limited to the more extended algebra without anything of any arbitrary character, except only the choice of a meaning for the fundamental symbols. In arithmetic, the symbols a, b, c, &c., mean simply numbers; let their meaning in the geometrical algebra be not numbers but lengths, or if numbers, let them be numbers of lengths, a given length being taken as the unit. And let each symbol be expressive not only of a length, but of a length in some particular direction; by which we mean that two lines are not to be denoted by the same symbol, unless they have not only the same lengths but the same directions.

This one fundamental change in the meaning of the things signified by letters is now all that need be made; for all the rest is absolutely the same as in arithmetic. For example, what is $a+b$? Let O A and O B be the lines represented in length and direction by a and b; having completed O A, that is, having passed from O to A through the proper length and in the proper direction, do that which would have given O B if O A had been nothing, or if A had been at O; that is, draw A C equal and parallel to O B, and in the same direction. The point C thus attained terminates a line O C, the length and direction of which is therefore to be denoted by $a+b$, since every process is to resemble that of arithmetic in everything but the meaning of the objects of calculation.





Again, required the meaning of ba? We must now choose a length and direction which is to be represented by 1; let this be O U. We are now to do with O A or a what we should have done with O U to make O B. Suppose for simplicity that O B is double of O U. To turn O U into O B, we must double its length, and let it revolve through a certain angle U O B. Do this with O A; that is, double its length, and make it, thus doubled, revolve to the position O C, so that the angles U O B and A O C are equal. Then O C must be that which is represented by ba; and the angle U O C is the sum of the angles U O B and U O A.

If we examine the fundamental definitions of the geometrically defined system of Algebra, we shall find that we have here described enough to deduce them all, and that we have done it by pure analogy. But also remark that analogy here means nothing but an identity of process; we have described the processes of addition and multiplication in terms which connect them so closely with the objects to which they are applied, and at the same time make the process so distinct from the subject-matter of the process, that when we change the subject-matter, we can still preserve the process. If then any other subject-matter could be found, such that, with reference to meanings of a and b derived from it, $a+b$ and ab could be consistently defined, or rather deduced, from 0 and 1, a new application of the rules of algebra would follow.

In the calculus of operations, the same steps might be made; and when this branch of algebra consisted of nothing but the separation of the symbols of operation and quantity in an arbitrary manner [Operation], analogy was the species of relation by which the deduction of results from this separation was connected with the results of common algebra. But this analogy was only the guide to the results, and not the proof of them: it became a proof when it was shown that the validity of the common algebra itself depended, not upon the whole meaning of the symbols, but upon that part of it which was preserved in the meanings of the symbols of operation.

RELATION (Logic). In the article Logic (cols. 345, 346) we have contended that any composition of relations is syllogism, and have stated our objection to the mode used by logicians of reducing such compositions to *their* syllogism, in which the only relation is identity. Without further controversy we shall proceed to statement, and nothing more, of a few heads of the general doctrine of syllogism. Those who desire more must consult a paper on the logic of relations, which will appear in vol. x., p. 2, of the Cambridge Philosophical Transactions.

Let L and M denote relations: X, Y, Z individual objects of thought, classes or attributes, it may be, considered as units of thought. Let LX denote anything which is an L of X, in the relation L to X.